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OPTIMIZATION OF THE MARMORA WATER TREATMENT PLANT FOR CONTROL OF TRIHALOMETHANES

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Optimization of the

Marmora

Water Treatment Plant for Control of Trihalomethanes

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PIBS 3713E

EXECUTIVE SUMMARY

BACKGROUND

The two main objectives of the study are:

1. Improvement of the water treatment plant performance to meet the new Ontario Drinking Water Objectives (ODWO) THMs guideline without compromising disinfection, to achieve a filter effluent turbidity of 0.1 NTU.

2. Sustaining long term performance through skills transfer to plant operating staff and recommendations for plant upgrades where required.

The optimization study was funded by the Ontario Ministry of the Environment (MOE), and is a cooperative public/private project between the MOE and RAL Engineering Ltd. By optimizing the performance of their existing facilities, municipalities should be capable of producing water that meets the new THMs objective and also be capable of improved particle removal without requiring costly upgrades.

Trihalomethanes (THMs) are by-products created when the chlorine used in the disinfection process reacts with naturally occurring organics. Trihalomethanes are suspected of increasing the risk of cancer following long term exposure. The Ontario government has lowered the guideline from a maximum acceptable concentration of 350 µg/L, measured as a single occurrence, to an interim maximum acceptable concentration of 100 µg/L based on a running annual average of four quarterly samples.

The associated treatment parameter of turbidity was also subject of the optimization effort. The ODWO for turbidity is 1 NTU, but current research indicates that a filter effluent turbidity of 0.1 NTU is desirable to provide protection from cryptosporidium. To reduce potential for disease outbreaks, this study will evaluate the feasibility of obtaining a turbidity of 0.1 NTU in the filter effluent.

The optimization of a water treatment plant consists of evaluating the existing treatment units, conducting laboratory testing to determine the best choice and dosage of the treatment chemicals and making changes to plant operation.

EXISTING CONDITIONS

The Village of Marmora serves a population of 1,444 (1991 Census). The Marmora Water Treatment Plant was built in 1962, and the plant is owned and operated by the Village. The source of raw water is the Crowe River.

A summary of historical data from November 1994 to October 1995 is presented as follows:

Parameters	Units	Range	Average
Turbidity - Raw Water:	NTU	0.35 to 1.50	0.72
Turbidity - Treated Water:	NTU	0.35 to 1.50	0.72
(individual analysis varied between Raw and Treated)			
Colour - Raw Water:	TCU	14 to 50	28
Colour - Treated Water:	TCU	6 to 30	17
pH - Raw Water:		7.2 to 7.9	7.6
pH - Treated Water:		6.9 to 7.7	7.3
Alkalinity - Raw Water:	mg/L-$CaCO_3$	66 to 88	74
Alkalinity - Treated Water:	mg/L-$CaCO_3$	61 to 80	69
THMs - Treated Water:	µg/L	83 to 157	125
THMs - Distribution System:	µg/L	90 to 176	123

Plant flows are generally: Average day 682 m^3/d
Maximum day flow 1,136 m^3/d.

The Marmora facility consists of a diatomaceous earth (DE) filtration plant including:

- ⇒ Intake pipe bringing the raw water to the plant by gravity.
- ⇒ Coarse screen.
- ⇒ Overflow to the Crowe River.
- ⇒ Detention chamber.
- ⇒ Filter chamber with ten rectangular filter elements.
- ⇒ Chlorine injection into the high lift pump suction pipe.
- ⇒ Vertical turbine high lift pump.

PERFORMANCE ASSESSMENT

After a site visit performed on June 12, 1996, conclusions related to the current plant operation were made and are summarized as follows:

- The finished water turbidity often did not meet the Ontario Drinking Water Objectives (ODWO). In general the filters were not removing turbidity.
- Based on water sampling performed during the summer of 1996, the colour in the treated water and in the distribution system frequently exceeded the ODWO of 5 TCU. While colour is not a health-related parameter, it can be an indication of precursors that will form THMs.
- The Village of Marmora has experienced THMs levels in excess of the new guideline. This problem was documented in July and August 1996, when analysis showed THMs levels at the water treatment plant ranging from 150 to 190 µg/L, and in the distribution system from 120 to 200 µg/L.
- The minimum amount of diatomaceous earth (DE) recommended for filter pre-coat is 0.5 kg/m^2 (0.1 lb/ft^2). Therefore, the minimum amount required for the ten filter elements at the Marmora plant is 11 kg (24 pounds). It was observed during the initial site visit that only 3.2 kg (7 lb) was used for pre-coating.

- The small amount of DE used for pre-coating and the absence of continuous coating or body-feed during filtration was suspected to be a significant contributor to poor turbidity removal and elevated THMs levels.
- The lack of on-line instrumentation for raw and treated water turbidity reduced the possibility for on-going monitoring and optimization of the filtration process by the operating staff.

ON-SITE TESTING AND PLANT OPTIMIZATION

The MOE Standards Development Branch conducted on-site bench scale evaluations in the fall of 1996 and in the summer of 1997. The primary objective of the study was to determine the optimum diatomaceous earth dosage required during pre-coating, the DE feed rate required during body-feed, and to evaluate the most suitable grade of diatomaceous earth for the Marmora plant to improve the filter run time and to optimize turbidity removal. The conclusions of the optimization study are summarized as follows:

Pre-Coat Dosages Applied

- Trial testing at the plant using 11.4 kg or half a bag of DE for pre-coating when added slowly in a slurry form provided an increase in filter run, a fast reduction of turbidity through the pre-coat filters, and an easier wash down at the end of the filter cycle.
- The turbidity of the treated water was not improved by increasing the DE pre-coat dosage from 11.4 kg to 17 kg and 22.7 kg.
- The levels of colour and chlorine residual in the treated water were not affected by the amount of pre-coat powder used.
- The 11.4 kg pre-coat loading showed the smallest pressure drop across the filters at the end of the operating day and provided the best overall results.

Body-Feed Rate Adjustments

- A body-feed rate of 58 g/min provided the smallest rate of increase in head loss over the filter cycle. However, a body-feed rate of 43 g/min was found to be adequate for the current village water demand. If the water demand increases in the future, an increased feed rate may be required.
- Colour and chlorine residual was not significantly affected by the changes in the body-feed rate.

Grades of DE Powder

- The 535 DE powder currently used at the plant for pre-coat and for the body-feed system produced the smallest pressure head loss through the filters at the end of the day.
- The Hyflo and 503 powders produced the lowest levels of turbidity in the treated water, but the difference between the different grades tested was not significant.
- The three different grades of powder tested produced similar levels of particle counts, showing there is no significant performance improvement with a finer DE grade.
- More than 98.5% of particles larger than 2 μm were removed on passing through the filters. This corresponds to 1.8 log removal. This is an acceptable performance for this type of filtration system.

CONCLUSIONS

The levels of turbidity in the treated water for the currently used 535 grade DE powder with a pre-coat dosage of 11.4 kg and a body-feed rate of 43 g/min varies between 0.3 to 0.4 NTU, with a raw water turbidity ranging from 0.5 to 1.5 NTU. Increasing the DE pre-coat and adding continuous body-feed has therefore significantly improved the effluent turbidity.

The filtration run duration before plugging has been improved during the high demand summer conditions from 4 hours to 11 hours, and the filtration run time during the winter is 24 hours before re-coating is required. The optimization of the diatomaceous earth filtration plant did not result in any significant improvement to the colour level in the treated water. However, chlorine residuals in the distribution system were held better than in previous summers and there were fewer colour, odour and taste complaints.

The absence of a clearwell at the plant put the population located close to the treatment plant at risk, since the water leaving the plant was not exposed to a sufficient contact time for proper inactivation of cysts and viruses.

RECOMMENDATIONS FOR PLANT SCALE MODIFICATIONS

The following is a summary of recommendations for plant modifications required to ensure that the Marmora Water Treatment Plant will comply with the ODWO for THMs, while maintaining adequate disinfection:

- Install a chlorine contact pipe (Installation completed in January 1998),
- Use chloramination (Implemented early March 1998),
- Use on-line turbidity meters.

Chlorine Contact Pipe

The chlorine contact pipe was installed in January 1998. The chlorine contact pipe is designed to provide a maximum of 45 minutes contact time at plant rated capacity. Free chlorine residual will be used as a primary disinfectant to provide proper inactivation of cysts and viruses. The chlorine is injected into the suction of the high lift pump, before the water enters the chlorine contact pipe.

With the new chlorine contact pipe, the level of THMs leaving the plant during the summer is expected to be between 70 and 80 μg/L at a contact time of 20 minutes and a free chlorine residual of 2 mg/L. The THMs formation expected during the winter will be much lower. The free chlorine is converted to chloramine prior to leaving the plant to prevent further formation of THMs.

The chlorine contact pipe arrangement is a double 'loop' pipe tied into the existing plant discharge such that the plant effluent is directed through the loops before entering the village distribution system. The chlorine contact pipe includes a total of 180 m of 500 mm (20 inches) diameter pipe installed in the road bed near the plant. A valve arrangement in the plant allows the operator to route the flow through two 'loops' in the winter when longer contact time is required, and to by-pass one 'loop' in the summer when less time is required and therefore reducing the time for THMs formation.

Chloramination

To maintain adequate chlorine residual in the distribution system, the free chlorine leaving the contact pipe is combined with ammonium sulphate solution to form chloramines. Chloramines do not react with organics to form THMs, and they are more stable than free chlorine providing a long lasting residual in the distribution system. The new chloramination system operation started in March 1998.

On-Line Turbidity Meters

Two (2) Hach 1720 C on-line turbidity meters were installed at the plant in 1996 to monitor turbidity removal. One meter was installed with a pump and feed line on the raw water intake, and the other on the high lift pump discharge.

COST ESTIMATE FOR IMPLEMENTATION

The construction of the 180 m, 500 mm diameter chlorine contact pipe including site work, piping, fittings and installation was awarded to Hadovic Construction in the fall of 1997, for a total construction cost of $ 72,800 (including taxes).

The cost to supply a day tank and mixer for the batch preparation of ammonium sulphate solution, one dosing pump, a chlorine residual analyzer, a recorder and fittings was approximately $7,000 (taxes not included), and was assumed by the MOE. The two (2) Hach 1720C on-line turbidity meters were purchased at a cost of $ 4,800 (not including taxes). This cost was also assumed by the MOE.

Ammonium sulphate is available in 22.7 kg (50 lb) bag. A total of approximately 4 bags should be used per month, for an estimated annual operating cost of $ 1,000/year. The overall consumption of chlorine gas is not expected to increase. Therefore, no increase in chlorine operating costs should be related to the process modification.

There has been additional consumption of DE for the pre-coat and the body-feed however, longer filter runs have reduced operator overtime costs.

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1.0 BACKGROUND

Trihalomethanes (THMs) are by-products created when the chlorine used in the disinfection process reacts with naturally occurring organics (eg. formed by decay of algae and vegetation) in raw water. Surface water containing high organics also often has high colour levels. The most common forms of trihalomethanes created are chloroform, bromodichloromethane, chlorodibromomethane and bromoform.

The formation of THMs is influenced by several factors:

• Free chlorine concentration	- higher Cl_2	= higher THMs
• Organic content	- higher organic concentration	= higher THMs
• pH	- higher pH	= higher THMs
• Temperature	- higher temperature	= higher THMs
• Time	- normally longer time	= higher THMs

Since the formation of trihalomethanes is associated with the presence of organics in the water, small inland lakes and rivers, which may contain more organics than large clear bodies of water have a greater trihalomethanes formation potential, especially during periods of high runoff.

The reason for adding chlorine to drinking water is to kill bacteria and other microorganisms that could cause numerous illnesses. However chlorine use leads to the presence of trihalomethanes and this is a cause for concern; studies have found an association between high levels of trihalomethanes in chlorinated drinking water, and slight increases in cancer following a long term exposure of more than 35 years.

Chlorine has an advantage over other disinfectants in that it persists many hours or for days and provides protection for the entire water distribution system. The benefit to public health of using chlorine as a disinfectant in drinking water far out-weighs the risk to health associated with the low levels of trihalomethanes created as by-products of chlorination.

In order to lower the health risk from trihalomethanes, the Canadian and Ontario governments have lowered their respective guideline limits from an "anytime" maximum acceptable concentration of 350 μg/L, measured as a single occurrence, to an interim maximum acceptable concentration of 100 μg/L based on a running annual average of four quarterly samples.

Disease outbreaks caused by giardia and cryptosporidium have been reported with increased frequency over the last decade in Canada and the US. These protozoan parasites (especially cryptosporidium) are more difficult to kill than bacteria with disinfectants, and therefore their removal by physical processes is vital. As a result, Health Canada is now examining the need for stricter standards for particle removal in water plants. The current Ontario Drinking Water Objective (ODWO) for turbidity that applies at the water treatment plant is 1 NTU, but current US research and experience now indicates that a filter effluent turbidity of 0.1 NTU is needed to provide protection from cryptosporidium. This study attempted to evaluate the feasibility to obtain a turbidity of 0.1 NTU in filter effluent, in the attempt to reduce potential for disease outbreaks.

Owners of water treatment plants and water distribution systems who provide water for consumption have legal responsibilities which are shared by all suppliers of food or drink. Owners and suppliers must take reasonable measures to ensure the water is fit for safe consumption.

This optimization study is funded by the Ontario Ministry of the Environment (MOE), and is a cooperative public/private project between the MOE and RAL Engineering Ltd. By optimizing the performance of their existing facilities, municipalities with a conventional water treatment plant (i.e. coagulation, flocculation, settling, filtration and disinfection or a diatomaceous earth filtration and disinfection as at Marmora) in many cases should be capable of producing water that meets the new THMs objective, and also be capable of improved particle removal, without resorting to costly upgrades. The optimization of a water treatment plant consists of:

- Documentation of existing facility.
- Assessment of the performance of each process unit.
- Verification of the hydraulic loading on each process.
- Testing to determine the best combination of treatment materials and the optimum dosages to achieve maximum removal of particles.
- Make required changes to plant operation at full-scale to ensure that changes will minimize the formation of THMs, but will not compromise the disinfection requirement.

2.0 OBJECTIVES

The two main objectives of the study are:

1. IMPROVEMENT OF MARMORA WATER TREATMENT PLANT PERFORMANCE

- Improve plant performance without major capital/equipment expenditures. Specific water quality objectives are listed below in decreasing order of priority:

  i To comply with the 100 µg/L ODWO for THMs in treated water as a running annual average of four (4) quarterly samples. This objective shall be met while ensuring proper removal and/or inactivation of disease-causing microorganisms such as bacteria and viruses, since this remains the most critical aspect of drinking water treatment.

  ii To improve particulate removal to reduce or eliminate disease risk from giardia and cryptosporidium. While the ODWO for turbidity is 1.0 NTU, the goal is to achieve 0.1 NTU in the filter effluent.

2. SUSTAINING LONG-TERM PERFORMANCE

- Skills transfer to plant operating staff to enable them to effectively control and adjust processes over the long term in response to raw water quality variations.

- Documentation of plant conditions with recommendations for up-grades and operational modifications.

3.0 DOCUMENTATION OF EXISTING CONDITIONS

The Village of Marmora serves a population of 1,444 (1991 Census). The Marmora Water Treatment Plant was built in 1962, and the plant is owned and operated by the Village. There are three operators on staff working between two to four hours per day at the plant. The source of raw water is the Crowe River. A plant survey was performed during a site visit on June 12, 1996 to prepare a detailed description of the existing equipment and the condition of operation. The survey is documented in Appendix A. A plant schematic is presented in Figure 3.1. The raw water characteristics are:

Colour:	14 to 50 TCU
Turbidity:	0.35 to 1.50 NTU
pH:	7.2 to 7.9
Alkalinity:	66 to 88 mg/L

Plant flows are generally:	Average day	682 m^3/d
	Maximum day flow	1,136 m^3/d.

The Marmora facility consists of a diatomaceous earth (DE) filtration plant including:

- ⇒ Intake pipe bringing the raw water to the plant by gravity.
- ⇒ Coarse screen.
- ⇒ Overflow to the Crowe River.
- ⇒ Detention chamber.
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- ⇒ Chlorine injection into the high lift pump suction pipe.
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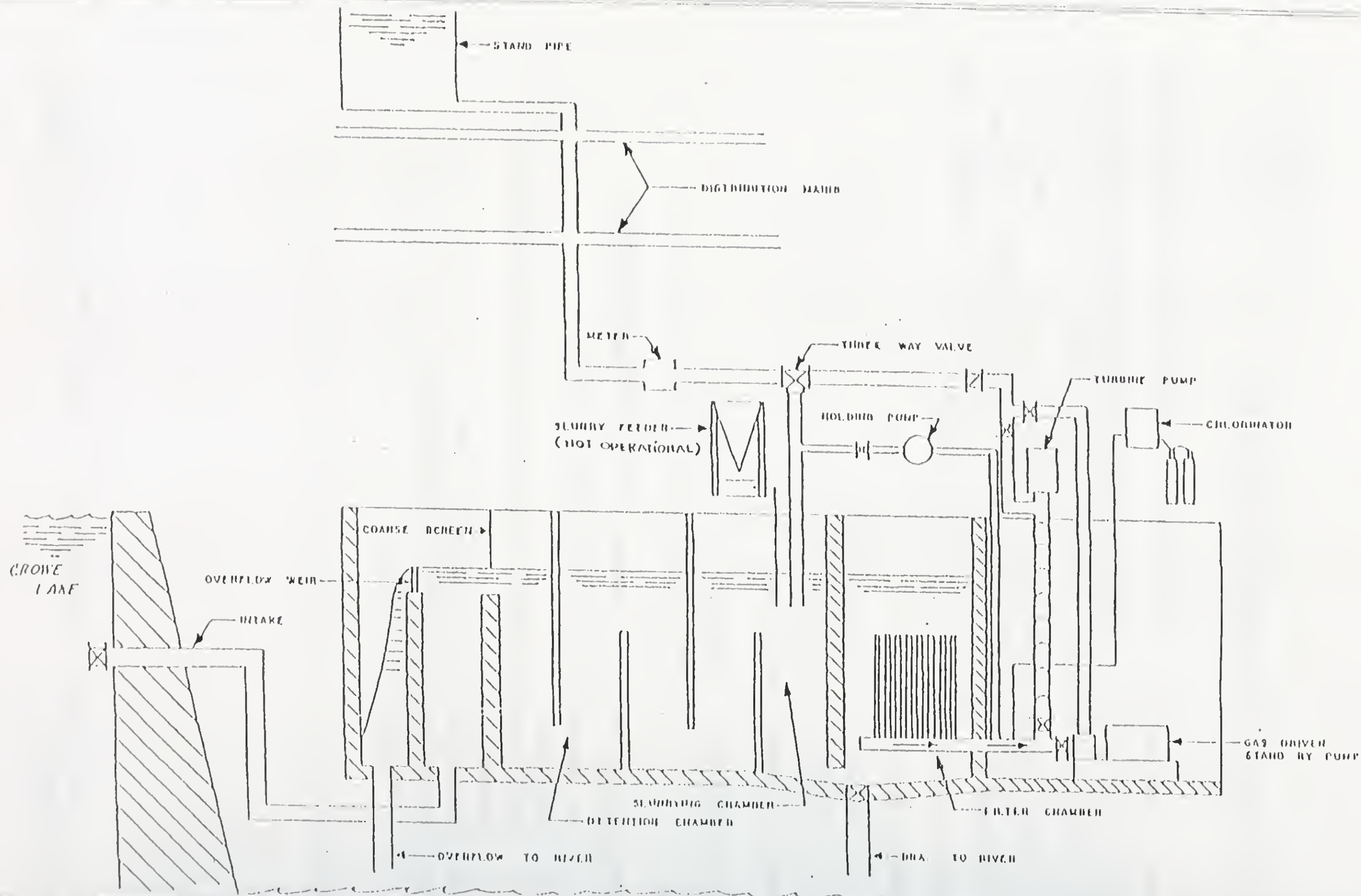

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DATE APRIL 1998 PROJ. No 96-D03

FIGURE 3.1 SCHEMATIC DIAGRAM OF MARMORA WATER SYSTEM

3.1 PROCESS UNITS

In diatomaceous earth filtration, raw water is passed through a uniform layer of filter media that has been deposited or pre-coated on a septum, a permeable material that supports the filter media. The septum is supported by a rigid structure called a filter element. As the water passes through the filter media and septum, insoluble particles of semicolloidal size and larger (i.e. turbidity) are captured and removed. There are five or six commonly used grades of filter media available. The type used at the Marmora plant is diatomaceous earth or diatomite, Celite grade 535.

The majority of the particles removed by the filter are trapped at the surface of the filter-media layer, with some being trapped within the layer. As the filter run proceeds, additional filter media, called body-feed is regularly metered into the influent water flow in proportion to the solids being removed. Without the regular addition of filter media as body-feed, the head loss across the pre-coat layer would increase rapidly. Instead, the turbidity causing particles intermingle with the body-feed particles so that the permeability of the cake is maintained as the thickness of the cake gradually increases. By maintaining cake permeability, the length of the filter cycle is extended.

Ultimately, a gradually increasing pressure drop through the filter system reaches a point where continued filtration is impractical due to pump damage by cavitation. The filtration process is then stopped, the filter media and collected turbidity are washed off the septum, a new pre-coat of filter media is applied, and filtration continues. The thickness of the initial layer or pre-coat of filter media is normally 1.6 to 3.2 mm (1/16 to 1/8 in).

3.1.1 Intake, Overflow and Detention Chamber

Water from the Crowe River enters the water treatment plant through a 250 mm (10 inch) screened intake installed in a small impoundment upstream of the nearby hydro generating dam. The water depth at the intake is approximately 3 m. The water flows by gravity from this point to the treatment plant. A static head of approximately 0.6 m between the river and the operating water level in the plant provides a sufficient supply to the filters.

A concrete overflow chamber receives the water from the intake line. An adjustable overflow weir establishes the operating water level in the detention and filter chambers. Water enters the filter side at any required rate, and the rest of the incoming water spills into a drain pit, where it flows by gravity back to the river below the nearby dam. The overflow chamber eliminates the need for an automatic water level control valve. It also permits a rapid flow of water through the intake line, which prevents clogging and freezing.

Water flows from the overflow chamber into a concrete detention chamber. The characteristics of the chamber are summarized as follows:

- Dimensions: approximately 4.6 m long and 1.5 m wide.
- Contact time at average day flow: 15 minutes (at 682 m^3/d).

The detention chamber has over and under baffles designed to provide mixing and contact time for powdered activated carbon (PAC). Powdered activated carbon (PAC) may have been fed into the water at the inlet of the detention chamber to remove the colour in the raw water, but this operation had not been used for many years since it was believed to create filter clogging and was inefficient at removing colour.

After the detention chamber, the water enters a slurry chamber ahead of the filters. The plant originally included a Wallace and Tiernan wet slurry feeder used for the diatomite body-feed system during the filtration cycle. The body-feed was injected into the slurry chamber. The operation of the body-feed system was discontinued a long time ago due to a misconception that the body-feed would shorten the duration of the filtration cycle and cause deterioration of the treated water quality.

3.1.2 Filter Chamber and Filter Elements

The filtration unit is made of ten rectangular filter elements with overall dimensions of 0.9 m by 1.2 m (3' by 4') each. The elements are covered with heavy polyester cloth custom shaped bags and pre-coated with diatomaceous earth. The filtered water is drawn through the diatomaceaous earth (DE), cloth and stainless steel filter elements to a collection manifold. This manifold runs through the concrete wall of the filter chamber where it is connected to the suction side of the high lift turbine pump.

3.1.3 High Lift Pump

There is one vertical turbine pump available at the plant. The pump has a capacity of 15 L/s (200 Igpm) and a power requirement of 11.2 kW (15 HP). The pump impeller/stator has been recently replaced and is in good condition. There were no issues related to high lift pumping. The suction head of the high lift pump is used to draw the water through the filter while the discharge head is used to pressurize the mains and fill the standpipe. A vacuum gauge is connected into the suction line ahead of the pumps. This gauge indicates the relative clogging load on the filter. Emergency power is not available but substantial storage capacity exists which allows some time for obtaining a generator.

3.1.4 Wastewater Disposal

Filter backwash which contains all the material filtered from the water and the spent DE is discharged to the Crowe River. The volume of backwash water is not metered.

3.1.5 Standpipe

The Marmora Water Treatment Plant does not have a clearwell on-site. The distribution system includes a standpipe, however there are houses located between the plant and the standpipe. Some houses are located as close as 40 metres from the plant. Therefore, some consumers were being provided with water that did not receive adequate disinfection. In the absence of sufficient chlorine contact time, there was an increased risk of waterborne disease within the village.

A mercury column altitude valve in conjunction with a telemetering system connected to the filtration plant controls the water level in the standpipe. When the water in the standpipe has reached its maximum level, a signal from the telemeter puts in operation a 0.75 kW (1 HP) holding pump, which recirculates water through the filter to hold the cake on the elements. The high lift pump then stops. All electric controls have "hand-off automatic" selectors so that the system may be run on manual or automatic.

3.2 CHEMICAL FEED SYSTEMS

The chemical feed systems used at the plant are summarized as follows:

Process Function	*Chemical*	*Locations Added*
Filter Media	Diatomaceous earth	Pre-coat in the filter chamber
Disinfection	Chlorine gas	High lift pump discharge

3.2.1 Diatomaceous Earth

At the time of the plant visit a pre-coat step was done by adding approximately 3.2 kg (7 lb) of diatomite in three galvanized pails filled with water and stirred with a broom handle. The resulting slurry was discharged into the previously filled filter chamber. Body-feed was not added since it was believed to plug the filter.

3.2.2 Chlorine

A chlorine solution, prepared from chlorine gas in a 68 kg (150 lb.) cylinder is applied to the water at the high lift pump suction. The water supply to the wall mounted gas chlorinator is controlled by a solenoid valve interlocked electrically with the high lift pump starter. This interlock stops the chlorination when the pump is off. The gas chlorinator is manually adjusted at a constant rate of approximately 4.5 kg/d (10 lb/d) during the summer months. Data collected at the plant in July and August 1996 indicated that the free chlorine residual leaving the plant is 4 mg/L. The measurement of chlorine residual is suspected to be inaccurate, since such high levels would be objectionable to most consumers. In addition, a minimum contact time was not being provided between the point of chlorine application and delivery of the chlorinated water to the nearest household.

3.3 FLOW MEASUREMENT

The rate of flow and total volume of water treated is indicated on a turbine flow meter installed on the pipe leaving the plant.

3.4 HISTORICAL DATA

A summary of historical data from November 1994 to October 1995 is presented in Table 3.1. This table summarizes monthly average values for turbidity, colour, pH, alkalinity and THMs found in the raw and the treated water. The water samples were analyzed by the MOE. The range and annual average from the data in Table 3.1 are summarized below:

Parameters	*Units*	*Range*	*Average*
Turbidity - Raw Water:	NTU	0.35 to 1.50	0.72
Turbidity - Treated Water:	NTU	0.35 to 1.50	0.72
(individual analysis varied between Raw and Treated)			
Colour - Raw Water:	TCU	14 to 50	28
Colour - Treated Water:	TCU	6 to 30	17
pH - Raw Water:		7.2 to 7.9	7.6
pH - Treated Water:		6.9 to 7.7	7.3
Alkalinity - Raw Water:	mg/L-$CaCO_3$	66 to 88	74
Alkalinity - Treated Water:	mg/L-$CaCO_3$	61 to 80	69
THMs - Treated Water:	µg/L	83 to 157	125
THMs - Distribution System:	µg/L	90 to 176	123

The variation of colour in the raw and the treated water for the Marmora plant is presented in Figure 3.2. The raw water colour reached its maximum value in January. The current water treatment consists of pre-coat filtration followed by chlorination. Although these two steps do achieve some reduction in water colour mainly due to bleaching by chlorine, further colour removal to consistently meet the MOE guideline of 5 TCU is not practical with DE filtration. The plant equipment originally included a device to feed powder activated carbon (PAC) thought to remove colour, organics and taste and odour. However, recent research shows PAC addition is ineffective in colour reduction (JAWWA, 1995) so this is no longer recommended.

The variation of turbidity in the raw and the treated water is presented in Figure 3.3. The raw water turbidity reached a peak in February and June. Based on historical data for 1994 and 1995, the way the plant was operated was inefficient at removing turbidity with average levels in the raw and the treated water of 0.72 NTU, indicating no removal through the pre-coat filters. The current Ontario Drinking Water Objective (ODWO) for turbidity that applies at the water treatment plant is 1 NTU, but current US research and experience now indicates that a filter effluent turbidity of 0.1 NTU is needed to provide protection from cryptosporidium.

High levels of THMs were recorded from 1992 to 1995 with levels ranging from 83 to 157 μg/L in the treated water (average: 125 μg/L), and from 90 to 176 μg/L in the distribution system (average: 123 μg/L). These levels exceeded the maximum acceptable concentration of 100 μg/L based on a running annual average of four quarterly samples.

TABLE 3.1 MARMORA WATER TREATMENT PLANT
MONTHLY WATER QUALITY RESULTS - 1994 and 1995
WATER SAMPLES ANALYZED BY THE MOE

	Nov-94	Dec-94	Jan-95	Feb-95	Mar-95	Apr-95	May-95	Jun-95	Jul-95	Aug-95	Oct-95	AVERAGE
TURBIDITY - RAW WATER (NTU)				1.50	0.48	0.35	0.83	1.00	0.50	0.65	0.45	0.72
TURBIDITY - TREATED WATER (NTU)	0.92	0.75	0.75	1.50	0.44	0.42	0.58	1.20	0.55	0.35	0.43	0.72
COLOUR - RAW WATER (TCU)			50	37	32	35	25	27	17	17	14	28
COLOUR - TREATED WATER (TCU)	12	30	30	17	17	17	15	13	18	9	6	17
pH - RAW WATER			7.6	7.2	7.9	7.8	7.8	7.8	7.3	7.5	7.5	7.6
pH - TREATED WATER	7.3	7.4	7.4	6.9	7.7	7.4	7.3	7.4	7.4	7.1	7.1	7.3
ALKALINITY - RAW WATER (mg/L-$CaCO_3$)			86.5	67.1	66.2	71.7	72.6	87.6	70.9	73.7	72.6	74.3
ALKALINITY - TREA. WATER (mg/L-$CaCO_3$)	68.5	80.1	80.1	61.6	61.2	66.1	67.1	75.3	70.7	67.1	65.7	69.4
THM - TREATED WATER (ug/L)		157										
THM - DISTRIBUTION SYSTEM (ug/L)		143										

Historical results for THM are summarized as follows:

	THM-Treated Water (ug/L)	THM-Distribution System (ug/L)
Jun-92	137	129
Dec-92	83	-
May-93	116	93
Oct-93	-	176
Mar-94	-	90
May-94	125	126
Jun-94	132	118
Aug-94	126	116
Apr-95	122	115
Average	125	123

FIGURE 3.2 COLOUR FOR MARMORA WTP

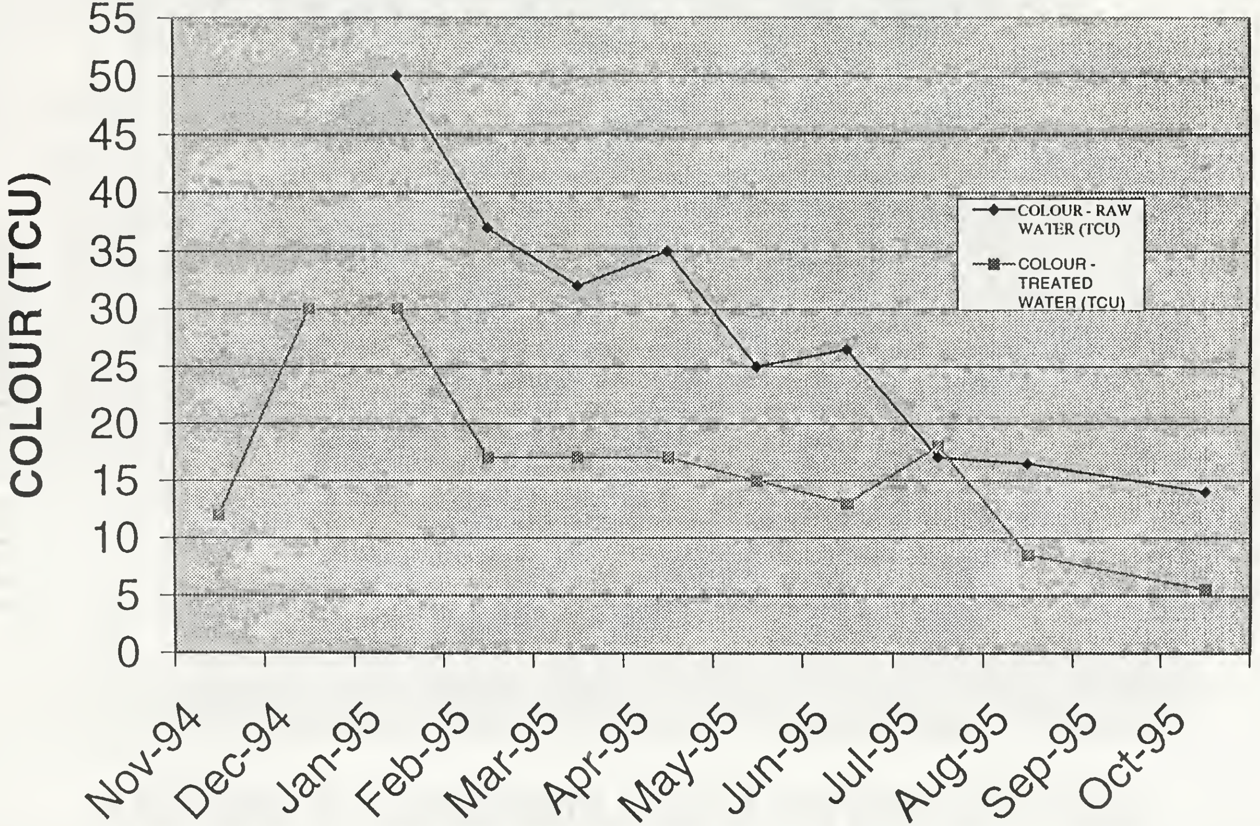
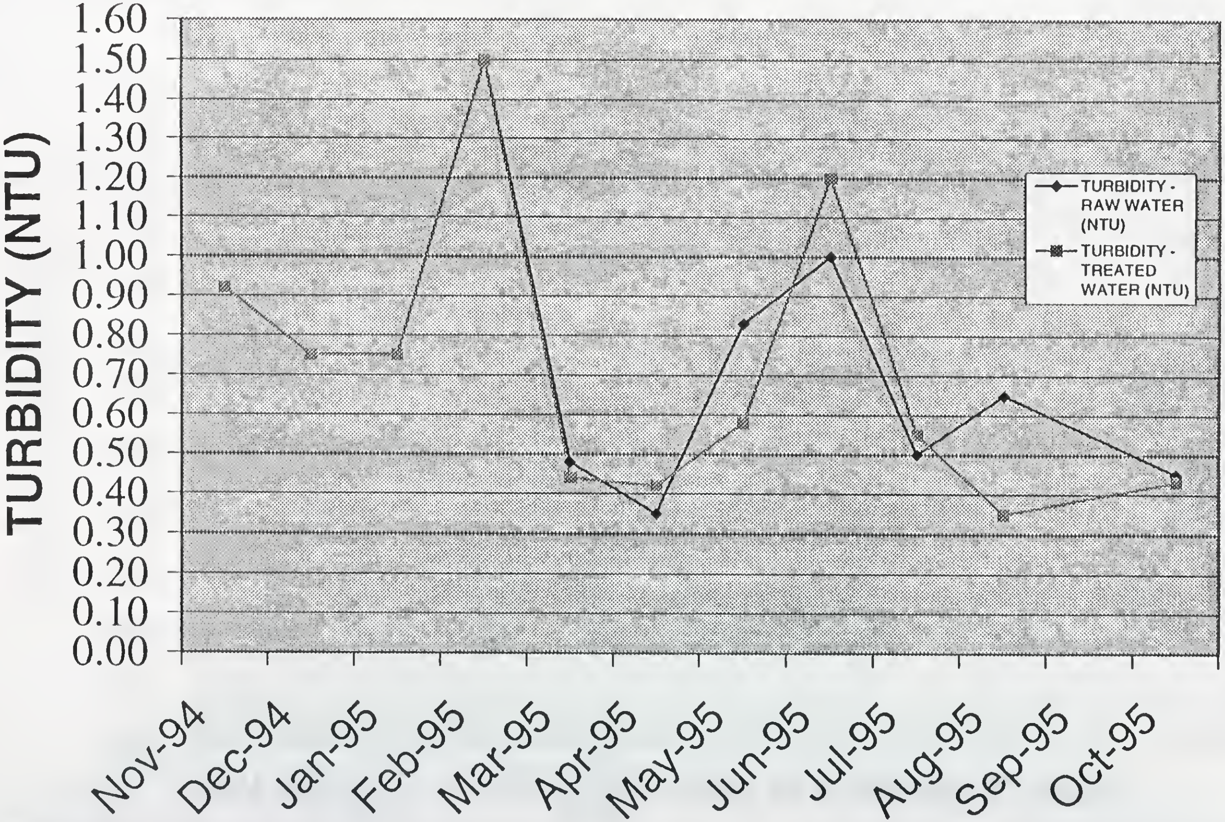


FIGURE 3.3 TURBIDITY FOR MARMORA WTP



4.0 PERFORMANCE ASSESSMENT

4.1 JULY AND AUGUST 1996 WATER SAMPLING

Additional water samples were collected at the treatment plant in July and August 1996, to establish a baseline for THMs versus the level of colour and Total Organic Carbon (TOC). Novamann laboratories (currently operating under Maxxam Analytics) analyzed the water samples. The results obtained from five weeks of sampling are summarized in Table 4.1. The operations data collected at the water treatment plant for the days of sampling including average daily flow, turbidity, raw water temperature and chemical dosages are presented in Table 4.2. The characteristics of the raw and the treated water based on water sampling performed during the summer 1996 are described as follows:

PARAMETERS	*RAW*	*TREATED*	*DISTRIBUTION SYSTEM*
Turbidity (NTU)	0.5 to 1.2	0.2 to 0.7	-
Colour (TCU)	11 to 18	2 to 8	4 to 10
pH	7.9 to 8.2	7.6 to 8.1	-
Alkalinity (mg/L-$CaCO_3$)	69 to 94	64 to 77	-
TOC (mg/L)	4.3 to 6.2	5.2 to 6.1	5.3 to 6.3
THMs (µg/L)	-	150 to 190	120 to 200

Based on water sampling performed during the summer 1996, the colour in the treated water and in the distribution system frequently exceeded the MOE criteria of 5 TCU for an average of 5 and 6 TCU respectively, but falls below the current federal standard of 15 TCU. Colour is referred to as an aesthetic parameter, but remains of importance since it is often indicative of high levels of organics in the water.

The level of turbidity in the treated water in 1996 improved compared to recorded historical data for 1994 and 1995, with average levels in the raw and treated water of 0.8 and 0.4 NTU respectively, showing a 50% removal. The improvement in turbidity removal is due to the increase in pre-coat dosage from 3.2 kg to 11 kg implemented after on-site testing performed at the plant in the summer of 1996.

The Village of Marmora continued to experience high levels of THMs. This problem increased during the summer where sampling performed in July and August 1996, showed THMs levels at the water treatment plant ranging from 150 to 190 μg/L, and in the distribution system from 120 to 200 μg/L.

The water samples taken in the distribution system for THMs analysis were quenched with sodium thiosulfate to remove any chlorine residual to stop any further reaction between free chlorine and organics. Quenched water samples will maintain the same level of THMs as existed at the time of sampling representing the quality experienced by the consumer. The water samples taken at the water treatment plant for THMs analysis were not quenched, to simulate the effect of additional contact time in the distribution system and the development of THMs.

The results presented in Table 4.1 show no removal of organics through the DE filters, with levels of total organic carbon (TOC) approximately the same in the raw and treated water. The concentration of TOC in the treated water remains relatively high at 5.5 mg/L. Based on THMs and TOC analysis, the relatively high level of TOC in the treated water is most likely responsible for the high THMs formation. There is no evidence of a direct relation between the level of colour in the water and the level of THMs formed. The lack of THMs-colour correlation is somewhat unexpected since in general the higher the colour, the higher the organic content, therefore producing higher THMs. In addition to the limited number of samples collected, other factors which may have contributed to the lack of correlation include the narrow range of colour value observed, and the analytical variability for THMs analysis. The detection limit of the analytical procedures and the method reference used by Novamann is summarized in Appendix B.

TABLE 4.1 JULY AND AUGUST 1996 WATER SAMPLING FOR MARMORA WATER TREATMENT PLANT
WATER SAMPLES ANALYZED BY NOVAMANN

PARAMETERS	WEEK 1 (16/07/96)	WEEK 2 (23/07/96)	WEEK 3 (30/07/96)	WEEK 4 (14/08/96)	WEEK 5 (20/08/96)	MINIMUM	MAXIMUM	AVERAGE
Turbidity - Raw Water (NTU)	1.2	0.5	0.6	1	0.8	0.5	1.2	0.8
Turbidity - Treated Water (NTU)	0.4	0.2	0.2	0.5	0.7	0.2	0.7	0.4
Colour - Raw Water (TCU)	17.9	14.6	14.9	10.7	11.2	10.7	17.9	13.9
Colour - Treated Water (TCU)	8	6	7	2	3	2	8	5
Colour - Distribution System (TCU)	10	8	6	4	4	4	10	6.4
pH - Raw Water	8.24	7.93	8.02	8.08	8.12	7.93	8.24	8.08
pH - Treated Water	7.69	7.57	8.11	7.99	7.77	7.57	8.11	7.83
Alkalinity - Raw Water (mg/L - $CaCO_3$)	72	74	69	74	94	69	94	77
Alkalinity - Treated Water (mg/L - $CaCO_3$)	69	67	69	64	77	64	77	69
TOC - Raw Water (mg/L)	6.2	5.1	4.3	5.5	6	4.3	6.2	5.4
TOC - Treated Water (mg/L)	6.1	5.2	5.3	5.6	5.4	5.2	6.1	5.5
TOC - Distribution System (mg/L)	6.3	5.4	5.3	5.7	5.8	5.3	6.3	5.7
THMs - Unquenched Treated Water (ug/L)	160	170	150	190	190	150	190	172
THMs - Quenched Distribution System (ug/L)	130	160	200	150	120	120	200	152

TABLE 4.2 JULY AND AUGUST 1996 WATER SAMPLING FOR MARMORA WATER TREATMENT PLANT OPERATING DATA COLLECTED AT THE WTP

PARAMETERS	WEEK 1 (16/07/96)	WEEK 2 (23/07/96)	WEEK 3 (30/07/96)	WEEK 4 (14/08/96)	WEEK 5 (20/08/96)	MINIMUM	MAXIMUM	AVERAGE
Average Daily Flow (m^3/d)	682	682	N/A	682	682	682	682	682
Turbidity - Raw Water (NTU)	N/A	N/A	N/A	N/A	N/A	-	-	-
Turbidity - Treated Water (NTU)	N/A	N/A	N/A	N/A	N/A	-	-	-
Temperature - Raw Water (Degree Celsius)	N/A	N/A	N/A	N/A	N/A	-	-	-
Free Chlorine Residual (mg/L)	4	4	N/A	4	4	4	4	4
Total Chlorine Residual (mg/L)	4.1	4.1	N/A	4.1	4.1	4.1	4.1	4.1
Chlorine Dosage (mg/L)	N/A	N/A	N/A	N/A	N/A	-	-	-

N/A: Not Available

4.2 PROCESS UNITS EVALUATION

4.2.1 Diatomaceous Earth Filters

After the site visit performed on June 12, 1996, conclusions related to the current plant operation were made and are summarized as follows:

- The current lack of on-line instrumentation for raw and treated water turbidity reduces the potential for on-going monitoring and optimization of the filtration process by the operating staff.
- The finished water from the plant frequently does not meet the MOE standard for drinking water colour as set out in the Ontario Drinking Water Objectives (ODWO). While colour is not a health related parameter itself, it can be a precursor for the formation of THMs. One method to limit the formation of THMs in coloured water is to disinfect with chloramines. This would necessitate the injection of ammonia into the treated water.
- The minimum amount of diatomaceous earth (DE) recommended for filter pre-coat is 0.5 kg/m^2 (0.1 lb/ft^2). The minimum amount required for the ten filter elements, two sides each having a septum dimension of 0.9 m by 1.2 m, is 11 kg (24 pounds). It was observed during the site visit that only 3.2 kg (7 lb) was used for pre-coating.
- The insufficient amount of DE used for pre-coating and the absence of continuous coating replenishment or body-feed during filtration was suspected to be a significant contributor to poor turbidity removal and elevated THMs levels.
- There were questions about the accuracy of the chlorine residual measurement performed at the plant; levels were very high, with free and total chlorine residual reported consistently at around 4 mg/L.

4.2.2 Disinfection

Disinfection of drinking water is a most important aspect of the treatment process. Harmful organisms in water such as bacteria, viruses or cysts can cause illness ranging from minor intestinal disorders to potentially fatal infections. Maintaining an effective disinfection process must be the overriding priority of the plant operations. For surface waters, chlorination with a 'free' residual is the most common and most practical method of disinfection. To be effective, the treated water must be low in turbidity (<1 NTU) as suspended particles can shield bacteria and virus from the effect of chlorine. In addition, turbidity levels greater than 0.1 NTU indicate an increased probability of chlorine resistant cysts being present.

To achieve a safe level of disinfection, it is necessary to dose the treated water with a sufficient amount of chlorine to produce a 'free' residual, and to give the chlorine sufficient time to inactivate the potentially harmful organisms. This is called the concentration-time factor or CT, also referred to as the primary disinfection stage. Sufficient disinfection must be achieved at the treatment plant before the first service connection. Current MOE guidelines call for a minimum residual of 0.5 mg/L for a minimum contact time of 30 minutes after filtration. This Ontario disinfection design guideline for water treatment plants is under review, and the new guideline may be similar to the Surface Water Treatment Rule (SWTR) promulgated by U.S. Environmental Protection Agency (U.S. EPA). The SWTR established CT values for chlorine, chlorine dioxide, ozone and chloramines required to achieve adequate inactivation of giardia cysts and viruses. For the purpose of calculating CT value, T is the time (in minutes) it takes the water, during peak plant flows, to move between the point of disinfectant application and a point where, C, residual disinfectant (in mg/L) concentration is measured just prior to the first customer. The calculation must take into account the degree of short circuiting in the storage tank.

For free residual chlorination, the CT required is based on the inactivation of giardia cysts in cold water. Giardia cysts are harder to inactivate by free chlorine than viruses, therefore, it is implied that proper inactivation of giardia cysts will ensure inactivation of viruses. Disinfection with chlorine is not effective for the inactivation of cryptosporidium, therefore it is necessary to perform adequate filtration at the water treatment plant for any municipality at risk of cryptosporidium disease outbreaks.

Secondary disinfection refers to the maintenance of a disinfectant residual throughout the distribution system to protect against bacterial re-growth or minor contamination. This "maintenance" residual is commonly achieved with 'free' chlorine, but alternatively can be converted to chloramine or 'combined' residual with the addition of ammonia. Chloramines have the advantage of being more stable and lasting much longer in the system. They also do not react with organics to form THMs. They are however, much less effective as a disinfectant and are very weak in inactivating viruses and cysts. Use of chloramine as a primary disinfectant is therefore not recommended.

The MOE guidelines recommend a minimum free chlorine residual of 0.2 mg/L at the end of the distribution system. The American Water Works Association (AWWA) recommends a residual of 1.0 mg/L of chloramine be maintained to prevent re-growth in the distribution system (AWWA, 1993).

The Marmora Water Treatment Plant does not have a clearwell. The Village has a standpipe and there are houses located between the plant and the standpipe. Therefore, some consumers are being provided with water that does not have adequate disinfection time to be considered safe. In the absence of sufficient chlorine contact time, there is increased risk of waterborne disease. To overcome this serious risk, it was proposed to Marmora that an oversized main could be designed and installed to satisfy the contact time requirement.

According to the SWTR, all community and non-community public water systems which use surface water source or a ground water under the direct influence of surface water must achieve a minimum of 99.9 percent (3-log) removal and/or inactivation of giardia cysts. A well operated diatomaceous earth plant that has been optimized for turbidity removal can be expected to achieve at least a 99 percent (2.0-log) removal of giardia cysts. The required CT will be based on 1.0-log inactivation of giardia cysts (3.0-2.0-log). Section 5.0 on process optimization demonstrates how the Marmora plant can be optimized to greatly improve turbidity removal.

Examples of CT calculations for winter and summer conditions are presented in Appendix C. The contact time (T) required in the chlorine contact pipe is estimated by using the rated plant capacity (1,136 m^3/d) for a free chlorine residual of 2 mg/L leaving the pipe, where chlorine is used as primary disinfectant. Maintaining a relatively high free chlorine residual of 2 mg/L in the contact pipe, will allow a reduction in the contact time required and therefore, reduce the required volume of the chlorine contact pipe. To reduce the THMs formation in the distribution system, expected to be high with a free chlorine residual of 2 mg/L, it is recommended to combine the free chlorine with ammonium sulphate to form chloramines at the outlet of the contact pipe. The results for the evaluation of contact time required for inactivation of giardia cysts for the winter and summer conditions are summarized in Table 4.3.

TABLE 4.3 Evaluation of the contact time required in the chlorine contact pipe for inactivation of giardia cysts

CONDITIONS	*Contact Time (minutes)* T
Winter condition (Water temperature = 0.5 °C)	47.5
Summer condition (Water temperature = 15 °C)	16.5

The results presented in Table 4.3 show that a longer contact time is required during the winter since lower water temperature reduces the rate of inactivation. The contact time required during the winter for a free chlorine residual of 2 mg/L is 47.5 minutes, and the contact time for the summer for the same chlorine residual is estimated to be 16.5 minutes.

5.0 ON-SITE BENCH SCALE EVALUATIONS

5.1 INTRODUCTION

The MOE Standards Development Branch staff conducted on-site and bench scale evaluations in the fall of 1996 and in the summer of 1997. The primary objective of the studies was to determine the optimum diatomaceous earth dosage required during pre-coating, and the DE feed rate required during body-feed to improve the filter run time, and to optimize turbidity removal.

5.2 PRELIMINARY TESTING

A staff member from the Ministry of the Environment performed preliminary on-site testing at the Marmora Water Treatment Plant during the week of October 28 to October 30, 1996. The purpose of the study was to evaluate and test adequate DE dosage for pre-coating to improve turbidity removal, and to test for the chlorine residual level in the treated water.

It was found by testing for chlorine residual with a recently purchased DR700, that the effective chlorine residual at the plant is approximately 2.5 mg/L and not 4 mg/L as reported in the past. The chlorine residual was mainly present in the free chlorine form. Samples at a Macs Milk store close to the southern extremity of the distribution system showed a chlorine residual of 0.23 mg/L.

5.2.1 First Pre-Coat Trial

A first trial was done by increasing the DE pre-coat dosage from 3.2 kg (7 lb) to 6.4 kg (14 lb) for the 6 a.m. re-coat. Investigation was also performed on how to obtain the best even coating on the vertical septum. It was concluded that a slower addition of the DE slurry was likely needed. A disused 200 L (45 gal) drum equipped with a 75 mm (3") marine screw impeller mixer with shaft and motor running at 1750 rpm was used to prepare a slurry solution to improve slurry mixing and to control addition rate.

Raw water turbidity at the plant was consistently at 0.8 NTU. The treated water turbidity was at 0.32 NTU. The total filter run time was 7.5 hours. The filter was then shut down and was thoroughly washed. It was found that doubling the DE dosage had no negative effect regarding premature filter clogging. The plant operator did not notice any particular improvement in this new method to perform the pre-coating.

5.2.2 Second Pre-Coat Trial

A second trial was performed at the plant with 11 kg of DE pre-coat. The drum-mixer was moved to the grid floor over the slurry chamber and the slurry preparation was done as follows:

- The drum was two thirds filled with water.
- The agitator was turned on and 20 scoops were added to the drum (11 kg).
- The drum was then filled with water to 150 mm (6") from the top.
- The bung from the side of the drum was removed allowing the mix to cascade into the filter chamber over a three-minute period.
- The bung was then reinserted leaving the drum two thirds full.
- The drum was filled with water, and a more diluted slurry discharge was repeated.
- The total slurry addition was done over a period of approximately 10 minutes.

On visible clearing of the water in the filter tank, the system was put back on-line. At first a large turbidity excursion was noted. After 15 minutes the turbidity fell to less than 0.5 NTU. The filtration system ran in automatic operation until 10:00 p.m. with a treated water turbidity of approximately 0.35 NTU and a run time of 8.5 hours. The system re-started at 7:30 a.m. and ran until 10:00 a.m. when 4 psi vacuum had developed. This filter run of 11 hours was apparently the longest ever observed. The operators washed down the filters and performed the re-coat using the agitator/drum flow system. It was reported that the filters were easier than usual to clean.

5.2.3 Conclusions

Trial testing at the plant using 11 kg or half a bag of DE when added slowly over 5 minutes in a slurry form provided an increase in filter run, a fast reduction of turbidity through the pre-coat filters, and an easier wash down. The existing old disused equipment can be used effectively for pre-coating.

The AWWA manual of water supply practices using pre-coat filtration (AWWA, 1988) recommends a minimum amount of DE for filter pre-coat of 0.5 kg/m^2 which corresponds to 11 kg (25 lbs) of pre-coating for the Marmora plant. Based on AWWA criteria, pre-coat loading ranging from 11 kg to 23 kg (25 lbs to 50 lbs) is required. Using less diatomaceous earth must be avoided since this will expose the population of Marmora to increased risk of illness due to improper filtration. The reason why the pre-coat is important is that all parts of the cloth (septum) must be covered with at least 1.6 mm (1/16") of DE to provide a proper barrier to particulates. Less thickness will allow potentially harmful organisms to pass through into the treated water since the filter cloth is a filter aid support not a filter in itself. During periods of higher turbidity in the river, the filter runs will be shorter.

A high free chlorine residual is required at the plant to maintain trace levels at the far reaches of the distribution system. The use of chloramination would help alleviate the situation.

5.3 PROCESS OPTIMIZATION

5.3.1 Objectives

The objectives of the study were to optimize the pre-coat DE dosage, the body-feed rate and evaluate the most suitable grade of diatomaceous earth for the Marmora plant to improve turbidity removal and filter run.

5.3.2 Introduction

A student from University of Western Ontario working under the supervision of Dr. Edmonds from the MOE Standards Development Branch conducted the process optimization study for the Village of Marmora Water Treatment Plant in June and July 1997. Detailed results of the optimization study are presented in Appendix D.

5.3.3 Instrument and Equipment Used

The apparatus used for the trial testing are summarized as follows:

1) Two on-line turbidity meters - Hach 1720C (for the raw and the treated water)
2) Portable turbidity meter - Hach 2100P
3) Colourimeter - Hach DR7OO with 450 & 525 nm filters
4) Differential Pressure Gauge
5) Flowmeter - Sparling
6) Top pan balance - OHAUS GT4800
7) Body-feed timer control - Carlo Gavazzi 1231 156
8) Particle Counter – Hiac/Royco 8000A

5.3.4 Procedure

The high lift pump was shut off first thing in the morning, the filter chamber was drained and the septum were hosed down thoroughly. After the septums were cleaned, the influent water was returned into the filter chamber to its normal operating level, and the recirculation pump was turned on. The detailed procedure for filter wash down is presented in the Operation Manual, Appendix E.

The proposed amounts of DE powder (11.4, 17 and 22.7 kg) were placed into the 200 L (45 I gallon) drum-mixer filled to approximately 150 mm (6") from the top with water. The drum was agitated with a 1750 rpm mixer. The drum was fitted with a 25 mm (1") valve discharge nozzle installed about 250 mm (10") above the base. Once the powder was placed in the drum the mixer was turned on for approximately five minutes creating a well-mixed slurry. The drum nozzle was then opened and the slurry was allowed to drain into the filter chamber. The effluent from the filter was recirculated back into the filter chamber until the water became visibly clear. The high lift pump was then turned on to pump the treated water to the elevated tank and distribution system.

The high lift pump ran all day unless cavitation resulting from high head loss through the filters occurred. If cavitation happened, the pump was shut down, the septum were washed and the cycle restarted.

The volumetric feeder used for the body-feed was adjusted as follows:

- The proposed feed rates (18 g/min, 43 g/min and 58 g/min) were selected with the body-feed timer. To insure accuracy of the timer, the body-feed rate was measured using an accurate top pan balance. This was done by measuring the total weight released in ten timer cycles.

The parameters analyzed are summarized as follows:

- Turbidity readings were taken every half hour for the raw and the treated water.
- Flow rate was measured every hour using the existing plant flow meter.
- The pressure drop that developed across the septum was measured every half hour.
- Colour was measured once a day using the colourimeter with a 450 nm blue end filter. The detailed procedure for colour analysis is presented in Appendix E.
- Water temperature was measured once a day by immersing a glass thermometer into the filter chamber.
- Free and total chlorine levels were measured twice a day using a Hach colourimeter with a 525 nm filter. The samples were taken from the tap at the plant and stored in a sealed jar. The analysis was made after approximately half an hour standing time. The detailed procedure for chlorine residual analysis is presented in Appendix E.
- Particle counts were performed twice a day for the raw and the treated water. Samples were taken by filling a 1-litre beaker. A cover was placed over the beaker to prevent any outside particles from entering the sample. The particle counter was set up to perform thirty 1-minute cycles on the water sample and then calculate the average particle count for particles 2 μm in size or greater.

5.3.5 Optimization of the DE Dosage for Pre-Coating

The testing was done from June 16 to 18, 1997, for the following conditions:

- On June 16, 1997, 11.4 kg (25 lb) of pre-coat Celite diatomaceous earth powder was tested which is the regular grade used at the plant. This dosage provided a pre-coat thickness of approximately 1.6 mm (1/16") on the septum.
- On June 17, 17 kg (37.5 lb) of Celite powder was tested to provided a pre-coat thickness of 2.4 mm (3/32") on the septum.
- On June 18, 22.7 kg (50 lb) of Celite powder was tested to provided a 3.2 mm (1/8") pre-coat thickness on the septum.

Cavitation in the high lift pump did not occur until after 10 hours of operation when the septum were pre-coated with 11.4 kg of DE powder. Cavitation occurred after approximately 5.5 hours of operation for a pre-coat load of 17 kg, and after 5 hours for a pre-coat of 22.7 kg.

The results showed that increasing the pre-coat load from 11.4 kg to 17 kg and 22.7 kg, did not change the turbidity of the treated water. Higher levels of turbidity observed at the end of the day when dosing 17 kg and 22.7 kg of DE powder were most likely caused by the presence of air bubbles in the water due to pump cavitation. The levels of colour and chlorine residual in the treated water were not influenced by the pre-coat dosage. The increased pre-coat load did substantially shorten the filter run.

5.3.6 Trial Testing with the Body-Feed System

Process optimization was performed with a body-feed system at the Marmora plant from July 2 to 4, 1997. A BIF volumetric feeder borrowed from the Bobcaygeon Water Treatment Plant was refurbished and used for the purpose of the testing. The conditions

tested are summarized as follows:

- On July 2, 11.4 kg of pre-coat DE powder, grade 535 was used with the body-feed system operated at its normal feed rate of 43 g/min.
- On July 3, the body-feed rate was reduced to 18 g/min.
- On July 4, the body-feed rate was increased to 58 g/min while keeping the initial filter pre-coat loading to 11.4 kg.

The results for the different body-feed rates tested regarding filtration run time were similar. The changes in the body-feed rate did not lead to cavitation in the pump for any rates tested. The body-feed rate of 58 g/min produced the smallest pressure drop across the filter at the end of the day.

The best results for turbidity removal were observed for a body-feed rate of 43 g/min. However, it is important to note that the lowest level of raw water turbidity was observed on July 2, which was the only day when the weather was sunny with only slight winds. This may have influenced the effluent turbidity.

The colour level and the chlorine residual of the treated water did not vary with changes in body-feed rates.

5.3.7 Trial Testing with Different Grade of DE

Process optimization was performed for different grades of DE powder from July 23 to 25, 1997. The conditions tested are summarized as follows:

- On July 23, an initial pre-coat of 11.4 kg of the regular 535 DE powder was used to coat the septum and the body-feed system was operated at a rate of 43 g/min. The 535 powder has a median pore size of 13.0 microns.
- On July 24, an initial pre-coat of 11.4 kg was done with Hyflo powder, and the body-feed system was operated with the same DE grade at a rate of 43 g/min. The Hyflo powder has a median pore size of 7.5 microns.
- On July 25, the DE grade tested was 503 powder while keeping the same conditions as described above. The 503 powder has a median pore size of 10.0 microns.

The results for the different grades of body-feed tested showed that the regular grade used at the plant, 535 powder, produced the best results regarding pressure head loss through the filters. This can be explained by the larger pore size of the 535 powder.

The turbidity of the treated water was affected by the grade of DE powder used. The Hyflo and 503 powders produced the lowest levels of turbidity in the filtered water. This may be explained by the fact that the powders have smaller pore sizes.

Particle count analyses performed for the three different grades of DE powders showed that the average particle count passing through the filters did not significantly change. The regular 535 DE powder produced the best results with an average of approximately 1,000 particles per litre greater than 2 micrometres. The Hyflo powder produced a filtered effluent with an average of approximately 1,600 particles greater than 2 micrometres, and the 503 powder averaged approximately 1,400 particles greater than 2 micrometres.

The levels of colour and chlorine residual were not affected by the different grades of body-feed powder tested.

5.3.8 Conclusions

The conclusions of the optimization study are summarized as follows:

Pre-Coat Dosage Changes Applied

- The turbidity of the treated water was not improved by increasing the DE pre-coat dosage from 11.4 kg to 17 kg and 22.7 kg. The best turbidity removal was observed at a dosage of 11.4 kg (25 lb).
- The levels of colour and chlorine residual in the treated water were not affected by the amount of pre-coat powder used.
- The 11.4 kg pre-coat loading showed the smallest pressure drop across the filters at the end of the operating day and provided the best overall results.

Body-Feed Rate Adjustments

- A body-feed rate of 58 g/min provided the smallest pressure head loss through the filter at the end of the day. However, a body-feed rate of 43 g/min was found to be an adequate rate for the current village water demand. If the water demand increases in the future, a increased feed rate may be required.
- Colour and chlorine residual were not significantly affected by the changes in the body-feed rate.

Grades of DE Powder

- The 535 DE powder used at the plant for pre-coat and for the body-feed system produced the smallest pressure head loss through the filters at the end of the day.
- The Hyflo and 503 powders produced the lowest levels of turbidity in the treated water, but the difference between the different grades tested was not significant. This conclusion is supported by particle counts analysis.
- The three different grades of powder tested produced similar levels of particle counts, showing there is no significant performance improvement with a finer DE grade.
- More than 98.5% of particles larger than 2 µm were removed on passing through the filters. This represents 1.8 log removal. This is an acceptable performance for this type of filtration system.
- Colour and chlorine residual levels were not affected by the grade of DE powder.

5.3.9 Recommendations

The main recommendations based on the process optimization study are the following:

- The Marmora plant should continue to use the DE 535 powder since it produced the best overall results.
- A pre-coat loading of 11.4 kg should be performed at the plant.
- A body-feed rate of 43 g/min is adequate for most raw water conditions.
- Increased body-feed rate may improve performance with very turbid raw water or higher flows.
- The optics for the on-line turbidimeters (Hach 1720C) should be cleaned once a week to maintain the accuracy of the equipment.

6.0 CONCLUSIONS

Increasing the DE pre-coat and adding continuous body-feed significantly improved the effluent turbidity from that recorded in 1994 and 1995. The levels of turbidity in the treated water for the currently used 535 grade DE powder with a pre-coat dosage of 11.4 kg and a body-feed rate of 43 g/min vary between 0.3 to 0.4 NTU, for a raw water turbidity ranging from 0.5 to 1.5 NTU. Marginal removal of turbidity was recorded in the past.

The filtration run has been improved during the summer conditions from 4 hours to 11 hours, and the filtration run time during the winter is 24 hours before re-coating is required. The optimization of the diatomaceous earth filtration plant did not result in any significant improvement of the colour level in the treated water.

Based on water sampling performed during the summer 1996, the colour in the treated water at the plant and in the distribution system was 5 and 6 TCU respectively. This marginally exceeded the MOE criterion of 5 TCU. Colour is referred to as an aesthetic parameter, but it is often indicative of high levels of organics in the water.

The Village of Marmora experienced high levels of THMs in the past. This problem was increased during the summer where sampling performed in July and August 1996 showed THMs levels at the water treatment plant ranging from 150 to 190 μg/L, and in the distribution system from 120 to 200 μg/L.

The absence of a clearwell at the plant put the population located close to the treatment plant at risk, since the water leaving the plant was not exposed to a sufficient contact time for proper inactivation of cysts and viruses. The construction of a chlorine contact pipe was undertaken in December 1997 to provide adequate contact time. With the new chlorine contact pipe, the level of THMs leaving the plant during the summer is expected to be between 70 and 80 μg/L with a contact time of 20 minutes and a free chlorine residual of 2 mg/L. The THMs formation expected during the winter will be much lower. The proposed relatively high free residual assumes the proposed chloramination system will be in place.

To maintain adequate chlorine residual in the distribution system, the free chlorine leaving the contact pipe will be combined with ammonia to form chloramines. Chloramines do not react with organics, present in the water, to form THMs, and they are more stable than free chlorine providing a long lasting residual in the distribution system.

There are two groups of people who need to take special care with chloraminated water: patients using home kidney dialysis equipment and fish tank owners. Chloramines must be removed from water used in the kidney dialysis process to prevent damage to the equipment, and from water that is used in fish tanks or ponds because of toxicity to aquatic life. Examples of public notifications were prepared to assist the Village of Marmora to better understand the process change at the water treatment plant, and are presented in Appendix G.

7.0 RECOMMENDATIONS

The following is a summary of recommendations for plant modifications required to ensure that the Marmora Water Treatment Plant will comply with the ODWO for THMs and colour, while maintaining adequate disinfection:

- Install a chlorine contact pipe (installation completed in January 1998),
- Perform chloramination (implemented in March 1998),
- Use of on-line turbidity meters.

The installation of on-line turbidimeters for the raw and the treated water was performed in 1996. The chlorine contact pipe was installed in January 1998, and the new chloramination system was made operational in March 1998.

7.1 CHLORINE CONTACT PIPE

The required chlorine contact time is normally provided by using a clearwell or a reservoir located in the vicinity of the water treatment plant. Building a new clearwell or a reservoir was eliminated as a viable option due to the high cost associated with its construction and the need for additional pumps. A more economical type of construction was recommended in the fall of 1996 to the Village of Marmora, consisting of a large diameter pipe installed underground beside the plant to provide the required contact time.

The pipe arrangement is a double 'loop' pipe tied into the existing plant discharge such that the plant effluent is forced through the loops before entering the village distribution system. The chlorine contact pipe includes a total of 180 m of 500 mm (20 inches) diameter pipe installed in the road bed near the plant. The first loop runs south from the plant for 45 m, turns 180 degrees and returns toward the plant. A second loop is connected to the first loop and installed in the same trench, between the first loop.

A valve arrangement was installed in the basement of the water treatment plant to allow the contact time to be varied for the winter and the summer. The valve arrangement offers the flexibility to have the water returning to the plant after its passage through the first loop. This provides a contact time of 22.5 minutes at the rated plant capacity (1,136 m^3/d) during the summer months when the raw water is above 15 °C (from June to September). The pipe arrangement will minimize the THMs formation during the summer considering that the free chlorine contact time required for proper inactivation of giardia cysts during the summer is only 17 minutes with a free chlorine residual of 2 mg/L. This pipe arrangement is also designed for the water to flow through the two loops to provide a contact time of 45 minutes at rated plant capacity during the winter, when the water temperature is below 15 °C. All valves are installed inside the plant, for ease of operation.

The pipes are made of steel reinforced concrete and are installed at a depth of approximately 1.7 m to keep them below natural frost penetration. A copy of the Certificate of Approval for the chlorine contact pipe is presented in Appendix F.

7.2 CHLORAMINATION

The chlorine contact pipe is designed to provide a maximum of 45 minute contact time at plant rated capacity. Free chlorine residual will be used as primary disinfectant to provide effective inactivation of cysts and viruses. The chlorine is injected into the suction of the high lift pump, before the water enters the chlorine contact pipe.

A second chemical, ammonium sulphate, is added just before the water leaves the plant to combine with the free chlorine and form chloramines. Disinfection with chloramines adds the benefit of a more persistent and consistent residual in the distribution system. Chloramines do not react with organics to form THMs. Chloramination of the Marmora drinking water supply started in March 1998.

Ammonium sulphate is available in 22.7 kg (50 lbs) bags. Approximately 4 bags should be used per month. The preparation of ammonium sulphate is done by dissolving the ammonium sulphate in water. A day tank with mixer is used to prepare the solution. The solution is applied into the pipe leaving the plant by using a small dosing pump with a capacity of 3.4 L/h. The procedure for the preparation of ammonium sulphate solution is presented in detail in Appendix E.

In the eventuality that the THMs remains above 100 µg/L during the summer, even after reducing the contact time in the chlorine pipe to 22.5 minutes, a flow splitter can be installed on the existing chlorinator to have the flexibility to provide a second chlorine injection point. The second injection point would be located immediately before the ammonium sulphate injection. This will allow the flexibility to apply a lower initial chlorine dosage entering the chlorine pipe, reducing the formation of THMs. The second chlorine injection would be used to raise the free chlorine residual to a limit of 2 mg/L so as to provide enough chlorine for protection to the extreme ends of the distribution system.

7.3 ON-LINE TURBIDITY METERS

Two Hach 1720 C on-line turbidity meters were installed at the plant in 1996 to monitor turbidity removal. One meter was installed on the raw water line, and the other on the high lift pump discharge.

The installation of on-line turbidity meters made possible the realization of the optimization study to evaluate the actual DE dosage and body-feed rate required for optimum turbidity removal and maximum filter run time.

8.0 COST FOR IMPLEMENTATION

The construction of the 180 m, 500 mm diameter chlorine contact pipe including site work, piping, fittings and installation was awarded to Hadovic construction in the fall of 1997, for a total construction cost of $ 72,800 (including taxes).

The cost to supply a day tank and mixer for the batch preparation of ammonium sulphate solution, one dosing pump, a chlorine residual analyzer, a 2-pen recorder and fittings was approximately $ 7,000, and was assumed by the MOE. The two (2) Hach 1720C on-line turbidity meters were purchased at a cost of approximately $ 4,800. This cost was also assumed by the MOE.

Ammonium sulphate is available in 22.7 kg (50 lb) bag. A total of approximately 4 bags should be used per month, for an estimated annual operating cost of $ 1,000/year. The overall consumption of chlorine gas is not expected to increase. Therefore, no increase in chlorine operating costs should be related to the process modification.

There has been additional consumption of DE for the pre-coat and the body-feed however, longer filter runs have reduced operator overtime reducing overall operating costs.

GLOSSARY AND LIST OF ABBREVIATIONS

Alum	: aluminum sulphate
CT	: Value required to achieve adequate inactivation and/or removal of cysts and viruses. T is the time (in minutes) it takes the water during peak hourly flow, to move between the point of disinfectant and a point where C, the residual disinfectant concentration (mg/L), is measured prior to the first customer.
d	: day
°C	: degree Celsius
DWSP	: Drinking Water Surveillance Program
ECR reagent	: Eriochrome Cyanine R
FID	: Flame Ionization Detector
ft	: foot
G	: flocculation energy gradient
Gt	: flocculation energy
GC/MS	: Gas Chromatograph / Mass Spectrometry
GAC	: Granular Activated Carbon
g	: gram
h	: hour
HFS	: hydroxylated ferric sulphate (Ferriclear)
ICP	: Inductively Coupled Plasma Atomic Emission Spectoscopy
IG	: imperial gallon
kW	: kilowatt
L	: litre
L/cap.d	: litres per capita per day
L/s	: litres per second
m	: metre
m^2	: square metres
m^3	: cubic metres

m^3/d	: cubic metres per day
m/h	: metres per hour (equivalent $m^3/m^2.h$ - filtration rate)
μg/L	: micrograms per litre
mg/L	: milligrams per litre
mm	: millimetre
mL/min	: millilitres per minute
min	: minute
NTU	: Nephelometric Turbidity Unit
OCWA	: Ontario Clean Water Agency
ODWO	: Ontario Drinking Water Objective
%	: percent
PACL	: polyaluminum chloride
PVC	: polyvinyl chloride
lb	: pound
rpm	: revolution per minute
SOR	: Surface Overflow Rate
SWTR	: Surface Water Treatment Rule
T_{10}/T	: This factor describes the baffling condition in the clearwell, and represents the ratio between T_{10}, which is the time it takes 10 percent of a dye or tracer to be detected at the basin outlet after it is injected into the basin influent flow, and the theoretical detention time for plug flow in pipelines and flow in a completely mixed chamber.
TOC	: Total Organic Carbon
THMs	: Trihalomethanes
TCU	: True Colour Unit
W/V	: weight/volume

REFERENCES

American Water Works Association Research Foundation - Optimizing Chloramine Treatment, 1993.

American Water Works Association – Manual of Water Supply Practices Precoat Filtration, 1988.

Environmental Science and Engineering Magazine. Drinking water Update - The Facts About Human Health and Aluminum in Drinking Water, January, 1997.

Journal American Water Works Association – Improving Precursor Removal, December, 1995, p. 71-82.

U.S. Environmental Protection Agency, Science and Technology Branch Criteria and Standards Division of Drinking Water. Guidance Manual for Compliance With the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources, October, 1990.

Ontario Ministry of the Environment, Environmental Approvals and Land Use Planning Branch. Guidelines for the Design of Water Treatment Works, April 1982.

APPENDICES

Plant Survey

Appendix A

PLANT	**Marmora Water Treatment Plant**
Shipping Address:	12 Bursthall St. P.O. Box 417, Marmora, Ont., K0K 2M0
Tel: (613) 472-2533	Fax: (613) 472-3015

PREPARED BY: R. A. LeCraw

DATE: Plant Visit June 12, 1996

STAFF:

Superintendent:	Garnet Brownson	Names of Operators:
No. of Operators:	3	Tom McQuaigg
Certified:	No	Murray Empey

Staff Schedule at the plant: 2 to 4 hours per day

PLANT CAPACITY:

Average Daily Flow:	150,000 Igal/d (682 m^3/d)
Maximum Daily Flow:	250,000 Igal/d (1,136 m^3/d)
Rated Plant Capacity:	250,000 Igal/d
Population Served:	1,444 (1994)

OPERATING AUTHORITY: Village of Marmora

YEAR OF CONSTRUCTION: 1962

SOURCE OF RAW WATER: Crowe River (Small damned impoundment)

WATER SHED CHARACTERISTICS: Limited residential, limited agricultural, recreational, former mining activity.

TYPICAL WATER CHARACTERISTICS:

	RAW	TREATED
Colour: TCU	28	17
Turbidity: NTU	0.72	0.4 to 1.2
pH:	7.6	7.3
Alkalinity: mg/L	74	70
TTHM: ug/L		160 (July 96)

CHEMICALS:

Coagulant: None

Coagulant Aid: None

Alkalinity/pH Adjustment: None

Disinfection: Type: Chlorine Gas
Dosage: 7 mg/L (Summer), 4.5 kg (10lb)/dayrate 14 to 15 h per day.
Injection Point: High lift discharge

Other: Diatomaceous Earth: Manual batch feed at beginning of each run only.

ANALYSIS DONE AT THE LAB:
Chlorine Residual only

LAB EQUIPMENT AVAILABLE:
DPD colour comparitor

PROCESS CONFIGURATION:

INTAKE: TYPE CONDITION NOTES

The intake is from a dam on the Crowe River. Water flows by gravity to the treatment plant. No problems were reported with this intake.

SCREENING: TYPE NO DIMENSIONS CONDITION NOTES

Coarse screen up-stream of dam — No reported problems.

LOW LIFT PUMPS: TYPE	NO	CAPACITY	CONDITION	NOTES
None. Gravity flow to the plant with a continuous raw water overflow.		Much higher than plant capacity	No reported problems.	Very efficient.

HIGH LIFT PUMPS: TYPE	NO	CAPACITY	CONDITION	NOTES
'In-line' Vertical Turbine	1, no standby	15 L/s (200 Igpm)	Good recently replaced	An old pump that still functions is stored in the plant and could be installed if the main pump fails.

MIXING: TYPE CONDITION NOTES

One hydraulic baffled mixing tank.

FLOCCULATION: TYPE NO DIMENSIONS VOLUME CONDITION NOTES

N.A.

CLARIFICATION: TYPE NO DIMENSIONS VOLUME CONDITION NOTES

N.A.

FILTERS:	TYPE	NO	DIMENSIONS	CAPACITY	CONDITION	NOTES
Diatomite filters	10 plates single tankage		1.2m X 1m (48" X 38")	1,136 m^3/d		

CLEARWELL/: ON-SITE RESERVOIR NO DIMENSIONS VOLUME BAFFLED: Y/N NOTES

None. There is no clearwell therefore no chlorine contact time. First customer is approximately 40m away from the plant.

PLANT CONTROL:

Flow (Manual Set/Auto): Flow is set by capacity limitation of high lift pump.

Level: High lift pump on-off operation is controlled by level from sensing standpipe reservoir.

PROCESS MONITORING:

	INSTRUMENT	MONITORING FREQUENCY	LOCATION	NOTES
Turbidity:	Not monitored. No turbidimeters			
pH:	Not monitored.			

Free Chlorine Residual:
DPD colour comparitor. Measured daily at the plant. Chlorine is reported to be 4.0 mg/L free residual most of the time. This is very high and would be objectionable to most consumers. It is also very corrosive.

Total Chlorine Residual: Not measured.

Temperature: Not measured.

Aluminum Residual: Not measured.

Colour: Not measured

Other: Diatomite Feed. Batch fed at the beginning of each filtration cycle. Preparation: 9.8 to 10lb per day in 2 to 3 washdown/reapplications. Water is re-circulated during pre-coating.

ISSUES:

The plant is not operated as it was originally intended. Diatomite Filters are pre-coated with diatomaceous earth (D.E.) but normally would require a continuous body feed of D.E. to allow a filter cake to build as suspended material is removed from the water. The current practice of pre-coating only would lead to short filter run as the media would become clogged quickly.

It was originally intended to feed powdered activated carbon for colour removal. This was discontinued more than 25 years ago. Consequently, the existing plant does not remove colour other than through the bleaching action of the chlorine hence the elevated THMs.

There is no monitoring of turbidity therefore, there is no way of knowing whether the filter pre-coat is sufficient or whether it has sloughed off. Most MOE analysis indicate the filter is not removing turbidity.

This plant and community is at significant risk due to incomplete treatment combined with inadequate disinfection practices. There is a need for action to be taken in the short term including:

- Turbidity monitoring of raw water and filter effluent.
- Review of chlorination and residual measurements.
- Addition of a retention tank or large dia. pipe to increase chlorine contact time.

The performance of the D.E. plant could also be improved with a continuous body feed of D.E. This will require refurbishment or replacement of the volumetric feeder. Addition of PAC should also be considered for colour removal which will also require a volumetric feeder.

CHECK LIST:

_	Copy of Certificate of Approval.	Not Available
_	Copy of DWSP report if available.	Not Available
_	Copy of monthly flows for the previous year.	
_	Copy of the monthly analysis for the previous year to evaluate plant performance for the raw water, settled water and plant effluent.	

Analytical Procedures used by Novamann

Appendix B

Detection Limit and Analytical Method Reference used by Novamann

PARAMETERS	MINIMUM DETECTION LIMIT(MDL)	ANALYTICAL METHOD	METHOD REFERENCE*
THMs	6 µg/L	Purge &Trap GC/MS	EPA 624
TOC	0.1 mg/L	UV/PEROX/FID	EPA 9060
residual aluminum	0.025 mg/L	ICP	EPA 6010
turbidity	0.1 NTU	Turbidity Meter	APHA 2130
true colour	1 TCU	Colourimetric	APHA 2120
pH	0.01	pH Meter	APHA 4500H
alkalinity	1 mg/L - $CaCO_3$	Titration	APHA 2320
ammonia + ammonium	0.05 mg/L	Colourimetric	APHA 4500
anions (NO_3, Cl, SO_4, F)	0.1 to 0.5 mg/L	Ion Chromatography	EPA 300.0
conductivity	1 umho	Conductivity Meter	APHA 2510
lead	0.002 mg/L	Graphite Furnace	EPA 7421
metals		ICP	EPA 6010
nitrite	0.1 mg/L	Colourimetric	APHA 4500
orthophosphate-P	0.005 mg/L	Colourimetric	APHA 4500

Note * : EPA : Environmental Protection Agency
APHA : American Public Health Association

Evaluation of Residual Chlorine Concentration
for Inactivation of Giardia Cysts

Appendix C

MARMORA WATER TREATMENT PLANT

C.1 Evaluation of the volume for the chlorine contact pipe for inactivation of giardia cysts with free chlorine during the winter:

NOTES:

* The SWTR establishes CTs for chlorine, chlorine dioxide, ozone and chloramines which will achieve a min. of 3-log inactivation of giardia cysts.

* A well operated D.E. plant meeting the performance criteria for turbidity removal can achieve at least 2-log removal of giardia cysts.

CT for 1-log inactivation = 95 (at 0.5 $^{\circ}C$ or lower, pH=7.5 and Conc. =2 mg/L)

Where C = Concentration (mg/L)
T = Contact Time (min)

Evaluation of Contact Time (T) during the Winter for a Free Chlorine Concentration of 2 mg/L:

T= CT for 1-log inactivation / 2

T= 95 /2

$\boxed{T = \mathbf{47.5\ min}}$

Volume Required for the Large Diameter Pipe:

Volume (m^3) = Rated plant capacity (m^3/d) x T (min) / 1440 min/d

Rated plant capacity= 1136 m^3/d

V = **37.5 m^3**

Length of Large Diameter Pipe:

L = Volume (m^3) / [3.1416 x D2/4 (m^2)]

Pipe Diameter = 0.5 m

$\boxed{L = \mathbf{191\ m}}$

MARMORA WATER TREATMENT PLANT

C.2 Evaluation of the volume for the chlorine contact pipe for inactivation of giardia cysts with free chlorine during the summer:

NOTES:

* The SWTR establishes CTs for chlorine, chlorine dioxide, ozone and chloramines which will achieve a min. of 3-log inactivation of giardia cysts.

* A well operated D.E. plant meeting the performance criteria for turbidity removal can achieve at least 2-log removal of giardia cysts.

CT for 1-log inactivation = 33 (at 15 ^{o}C, pH=7.5 and Conc. = 2 mg/L)

Where C = Concentration (mg/L)
T = Contact Time (min)

Evaluation of Contact Time (T) during the Summer for a Free Chlorine Concentration of 2 mg/L:

T= CT for 1-log inactivation / 2

T= 33 /2

$\boxed{\text{T= } \mathbf{16.5\ min}}$

Volume Required for the Large Diameter Pipe:

Volume (m^3) = Rated plant capacity (m^3/d) x T (min) / 1440 min/d

Rated plant capacity= 1136 m^3/d
V = **13.0 m^3**

Length of Large Diameter Pipe:

L = Volume (m^3) / [3.1416 x D2/4 (m^2)]

Pipe Diameter = 0.5 m

$\boxed{\text{L= 66 m}}$

Process Optimization Study

Appendix D

Wednesday, July 2, 1997
25 lbs of pre-coat powder used with body feed rate of 43 grams/minute

RESULTS:

Fixed Turbidity - 1720 Portable Turbidity - 2100

Time	Influent	Filtrate	Influent	Filtrate	Pressure Head (In.H2o)	Pressure Head (Psi)
10:30 AM	0.543	0.358	0.871	0.4	17 7/8	0.645
11:00 AM	0.537	0.362	0.74	0.4	18 15/16	0.683
11:30 AM	0.534	0.35	0.71	0.39	20 3/8	0.735
12:00 PM	0.528	0.339	0.7	0.4	21 3/4	0.785
12:30 PM	0.521	0.329	0.68	0.39	23 15/16	0.864
1:00 PM	0.517	0.328	0.7	0.4	25 5/16	0.914
1:30 PM	0.516	0.316	0.71	0.43	27	0.974
2:00 PM	0.519	0.313	0.63	0.38	29	1.05
2:30 PM	0.511	0.308	0.59	0.34	30 13/16	1.11
3:00 PM	0.66	0.307	0.6	0.4	32	1.15
3:30 PM	0.651	0.306	0.61	0.36	33 15/16	1.22
4:00 PM	0.647	0.3	0.67	0.4	35 3/16	1.27
4:30 PM	0.671	0.297	0.64	0.33	37 1/8	1.34
5:00 PM	0.667	0.301	0.61	0.34	39 1/8	1.41
5:30 PM	0.669	0.301	0.64	0.33	41 1/4	1.49
Average:	0.579	0.321	0.659	0.379	error = +-1/8	error=+-.004
Median:	0.537	0.313	0.670	0.390		
Deviation:	0.070	0.022	0.072	0.031		

Chlorine Tests

	1/2 Hour Wait		Immediately	
Time	Free	Total	Free	Total
11:30 AM	1.130	1.470	2.170	2.780
5:15 PM	0.350	1.490	*1.49	1.910

*Dilluted with 5cc Pipette

Time	Flow
10:30 AM	1.52
11:30 AM	1.52
12:30 PM	1.52
1:30 PM	1.52
2:30 PM	1.52
3:30 PM	1.52
4:30 PM	1.52
5:30 PM	1.52

Colour Test

Time	Colour
11:55 AM	3.000

Time	Water Temp.
11:50 AM	25.5

Thursday July 3, 1997

25 lbs. of pre-coat powder used with body feed rate of 18 grams/minute

RESULTS:

	Fixed Turbidity - 1720		Portable Turbidity - 2100			
Time	Influent	Filtrate	Influent	Filtrate	Pressure Head (In.H2o)	Pressure Head (Psi)
9:00 AM	0.685	1.158	0.81	1.12	12 7/8	.465
9:30 AM	0.892	0.611	0.98	0.51	13 9/16	0.489
10:00 AM	0.87	0.604	1.08	0.48	14 3/8	0.519
10:30 AM	0.813	0.58	1.04	0.48	16 3/16	0.584
11:00 AM	0.836	0.561	0.86	0.43	17 5/16	0.625
11:30 AM	0.856	0.542	0.8	0.44	19 7/8	0.717
12:00 PM	0.801	0.527	0.82	0.45	21 5/8	0.78
12:30 PM	0.843	0.549	0.87	0.4	23 3/8	0.844
1:00 PM	0.844	0.563	1.01	0.42	26 5/8	0.961
1:30 PM	0.833	0.515	1.02	0.36	28 7/16	1.03
2:00 PM	0.834	0.527	0.73	0.39	31 1/8	1.12
2:30 PM	0.827	0.485	0.76	0.38	33 3/8	1.2
3:00 PM	0.822	0.435	0.75	0.38	35 13/16	1.29
3:30 PM	0.839	0.437	0.91	0.38	38 3/4	1.4
4:00 PM	0.81	0.411	0.83	0.38	41 5/8	1.5
4:30 PM	0.817	0.417	0.81	0.39	44 1/8	1.59
5:00 PM	0.815	0.416	0.87	0.4	47 3/16	1.7
Average:	0.826	0.511	0.879	0.417	error = +-1/8	error=+-.004
Median:	0.833	0.527	0.860	0.400		
Deviation:	0.043	0.170	0.109	0.176		

Chlorine Tests

	1/2 Hour Wait		Immediately	
Time	Free	Total	Free	Total
12:05 PM	1.040	1.420	*1.76	2.750
4:05 PM	1.140	1.420	*1.52	2.740

*Dilluted with 5 cc pipette

Time	Flow
9:00 AM	1.52
10:00 AM	1.52
11:00 AM	1.52
12:00 PM	1.52
1:00 PM	1.52
2:00 PM	1.52
3:00 PM	1.52
4:00 PM	1.52
5:00 PM	1.52

Colour Test

Time	Colour
4:45 PM	3.000

Time	Water Temp.
12:15 PM	25.5

Friday July 4, 1997
25 lbs. of pre-coat powder used with body feed rate of 57 grams/minute

RESULTS:

	Fixed Turbidity - 1720		Portable Turbidity - 2100			
Time	Influent	Filtrate	Influent	Filtrate	Pressure Head (In.H2o)	Pressure Head (Psi)
9:20 AM	0.796	5.612				
9:30 AM	0.795	0.87	1.24	1.12	13 3/16	0.476
10:00 AM	0.992	0.424	1.11	0.48	14	0.501
10:30 AM	0.933	0.407	0.73	0.43	14 3/4	0.529
11:00 AM	0.836	0.4	0.88	0.45	15 1/8	0.55
11:30 AM	0.837	0.391	0.85	0.44	16 3/8	0.591
12:00 PM	0.843	0.385	0.86	0.43	17 1/4	0.623
12:30 PM	0.863	0.375	0.89	0.34	18 9/16	0.67
1:00 PM	0.849	0.356	0.71	0.36	19 9/16	0.706
1:30 PM	0.841	0.361	0.73	0.37	20 5/8	0.744
2:00 PM	0.843	0.359	0.72	0.36	21 9/16	0.778
Average:	0.857	0.379	0.796	0.398	error = +-1/8	error=+-.004
Median:	0.843	0.391	0.855	0.430		
Deviation:	0.058	1.569	0.177	0.230		

Chlorine Tests

	1/2 Hour Wait		Immediately	
Time	Free	Total	Free	Total
10:35 AM	0.230	0.380	*1.87	2.750
12:35 PM	1.140	1.580	*1.47	2.970

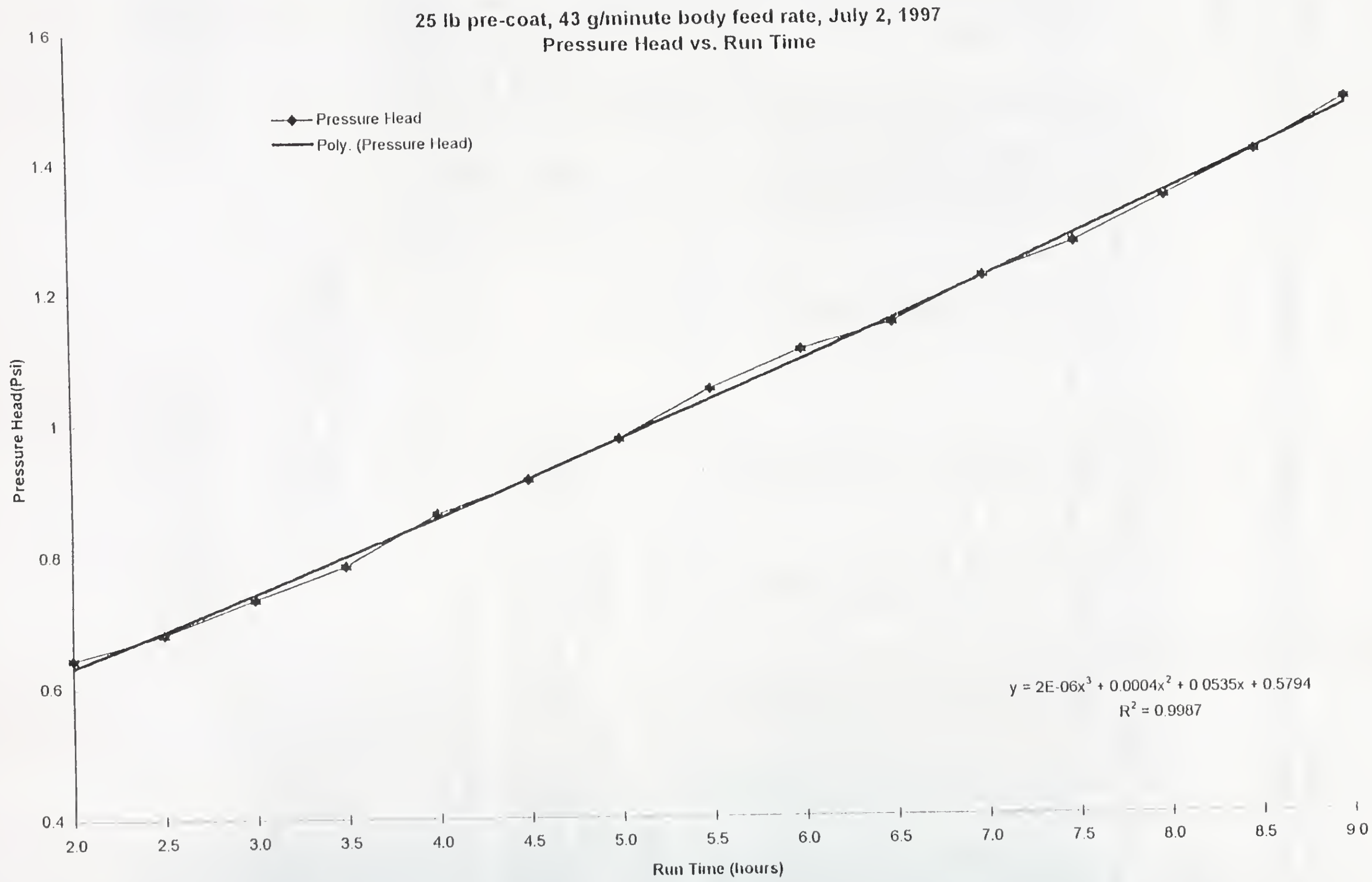
*Dilluted with 5 cc pipette

Time	Flow
9:30	1.5
10:30	1.5
11:30	1.5
12:30	1.5
1:30	1.5
2:30	1.5

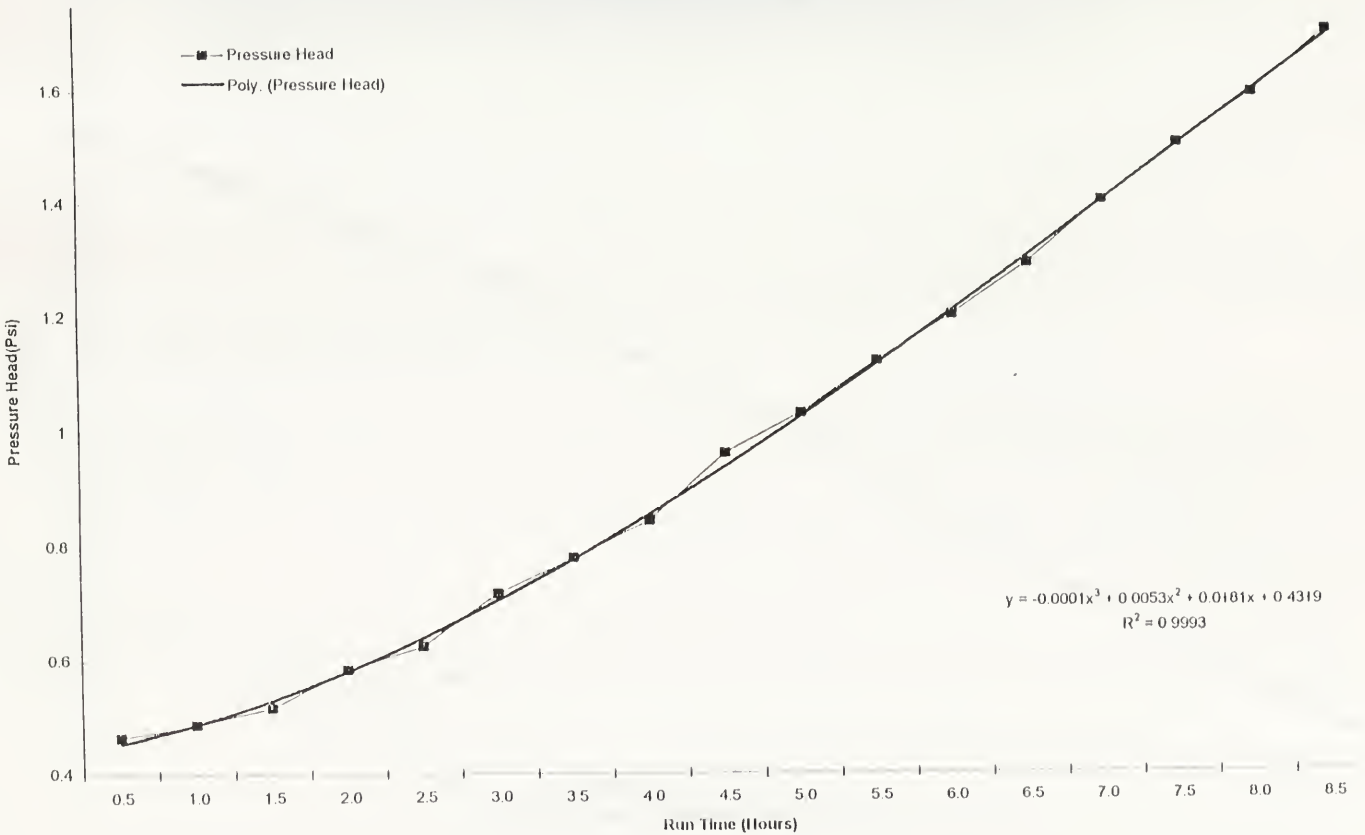
Colour Test

Time	Colour
12:40 PM	3.000

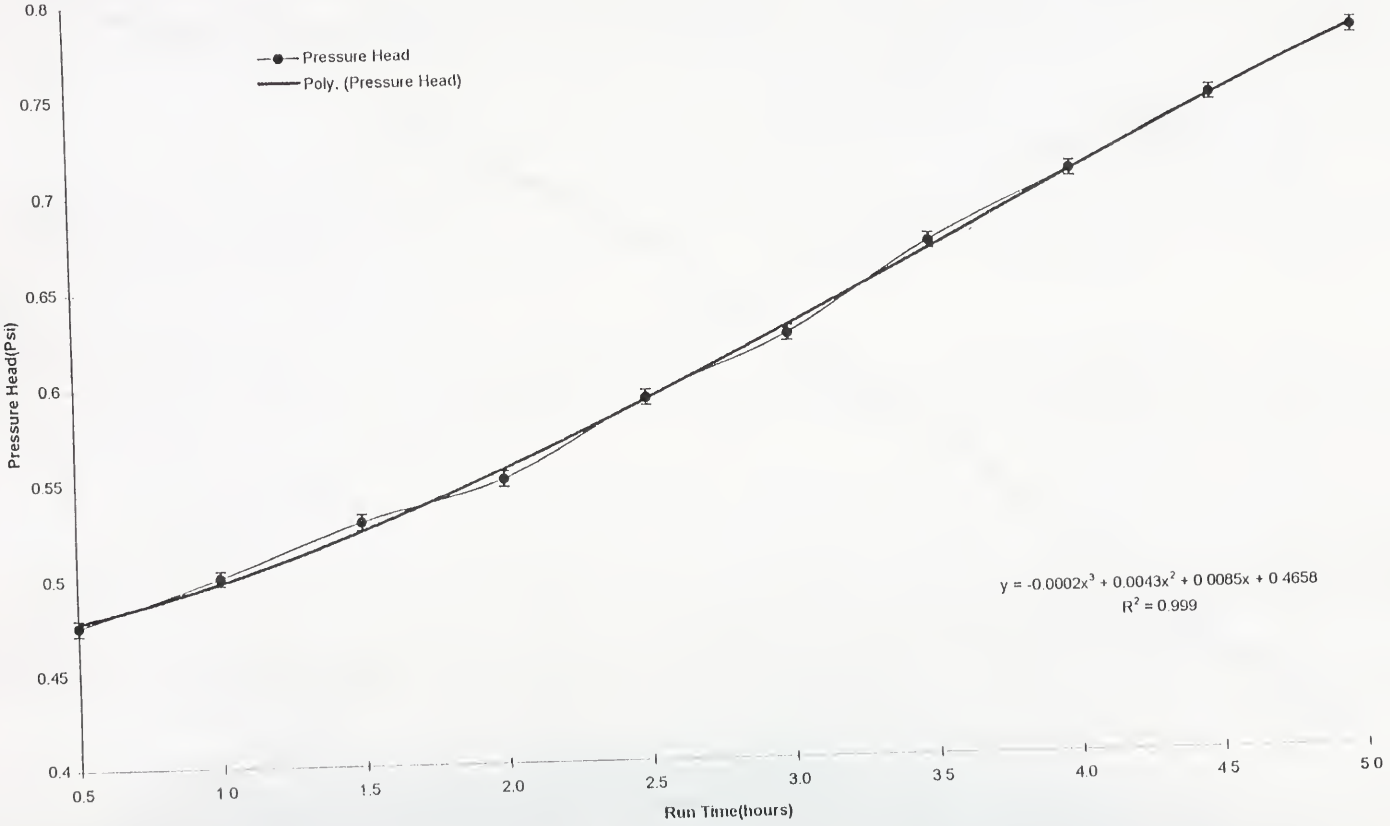
Time	Water Temp.
12:40 PM	24.5

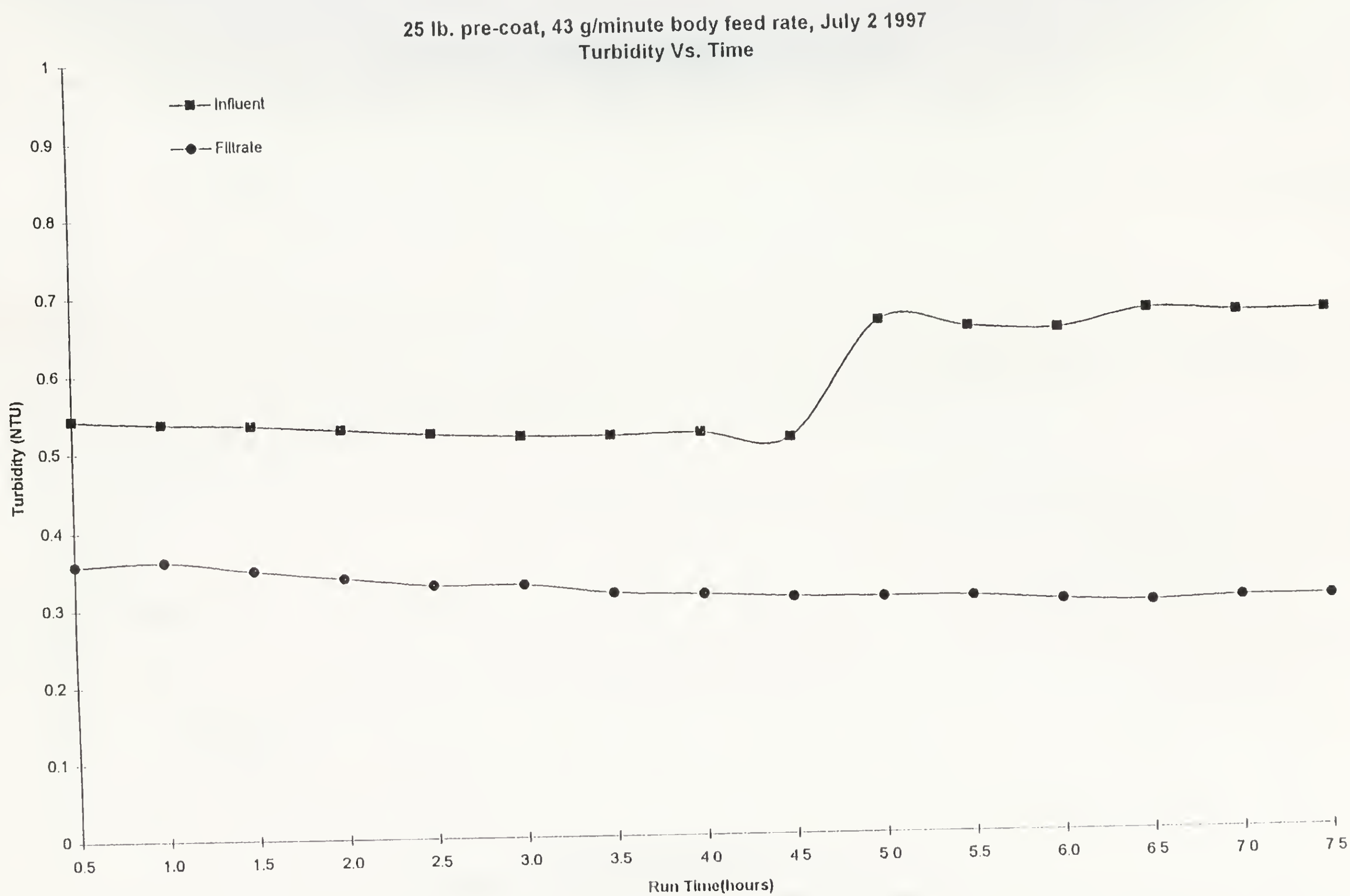

25 lb pre-coat, 43 g/minute body feed rate, July 2, 1997
Pressure Head vs. Run Time
Pressure Head
Poly. (Pressure Head)
Pressure Head(Psi)
Run Time (hours)
y = 2E-06x^3 + 0.0004x^2 + 0.0535x + 0.5794
R^2 = 0.9987
1.6
1.4
1.2
1
0.8
0.6
0.4
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0

25 lb pre-coat, 18g/minute body feed rate, July 3, 1997
Pressure Head vs. Run Time

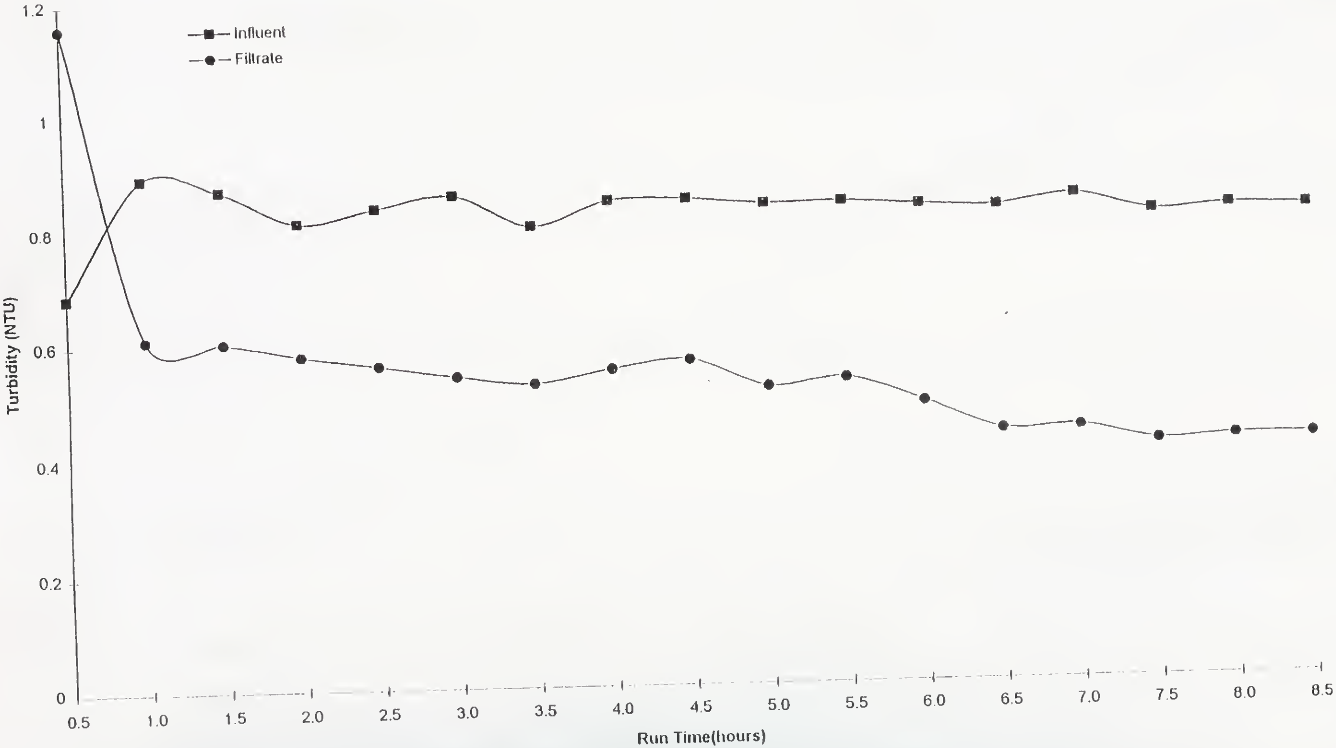


25 lb pre-coat, 58 g/minute, July 4 1997
Pressure Head Vs. Run Time

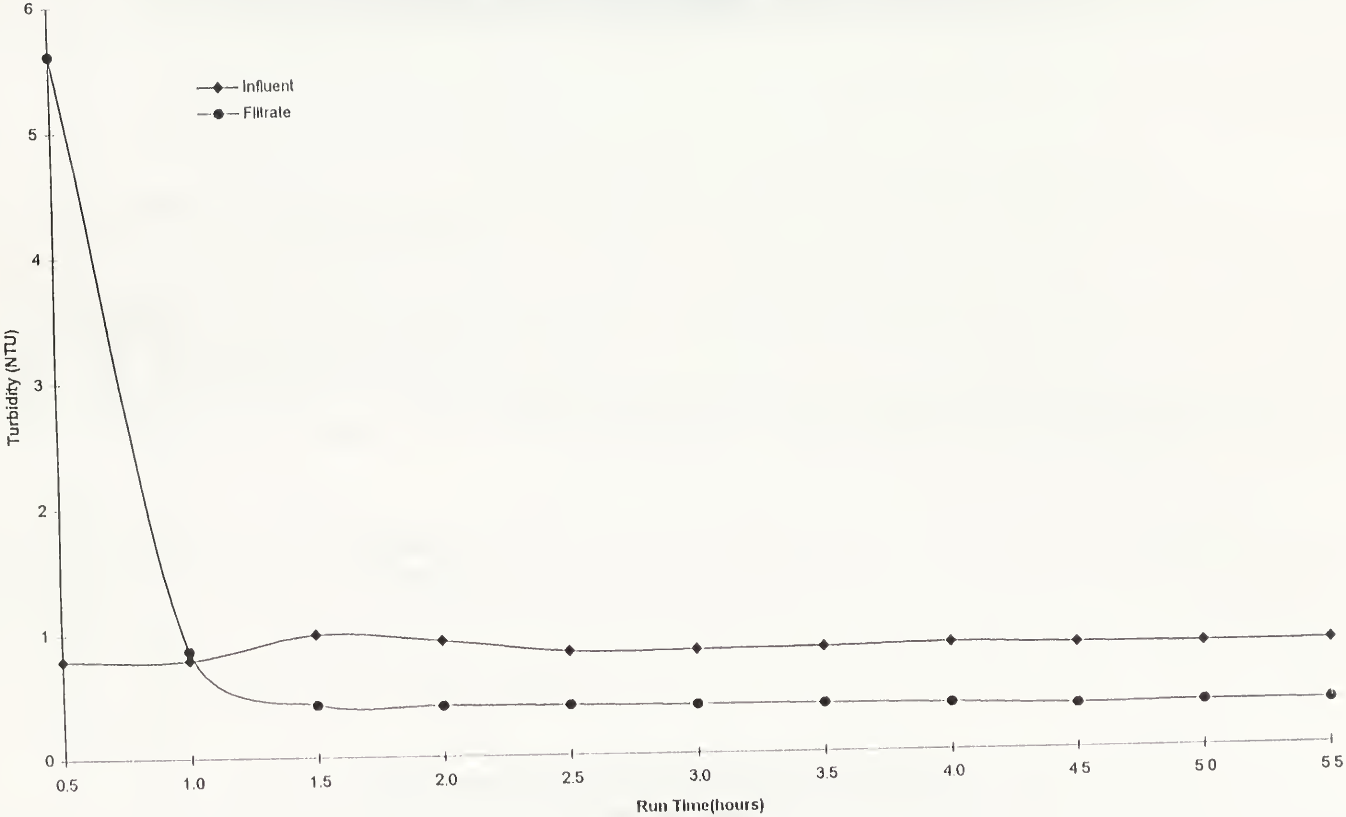



25 lb. pre-coat, 43 g/minute body feed rate, July 2 1997
Turbidity Vs. Time
Influent
Filtrate
Turbidity (NTU)
Run Time(hours)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5

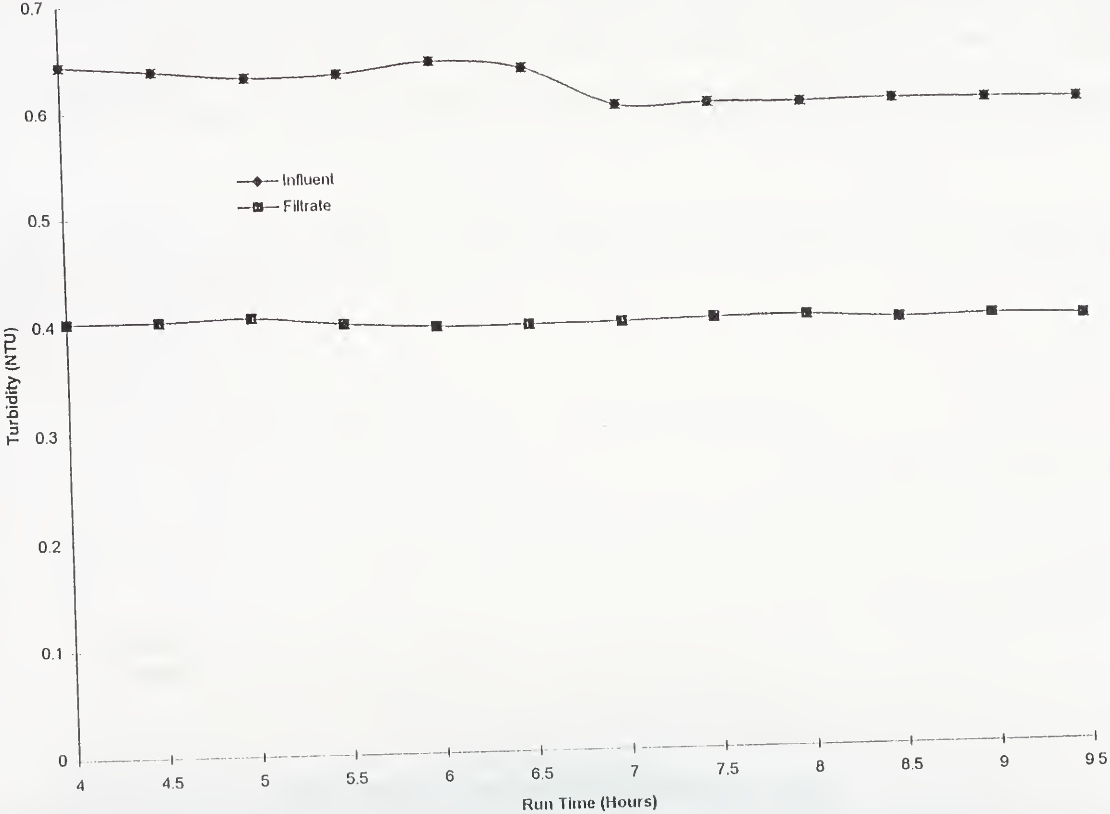
25 lb. pre-coat, 18 g/minute body feed rate, July 3 1997
Turbidity Vs. Time

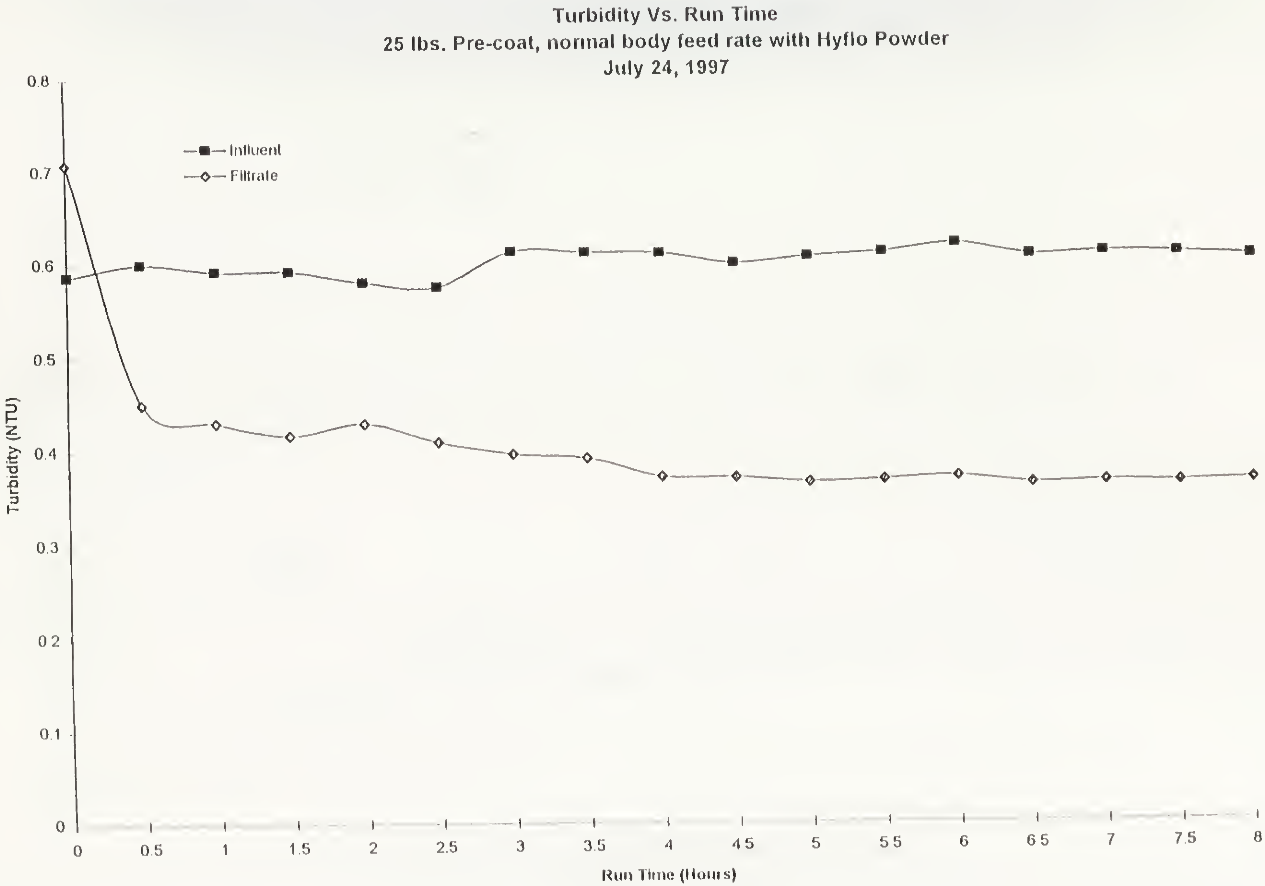


25 lb. pre-coat, 58 g/minute body feed rate, July 4 1997
Turbidity Vs. Time

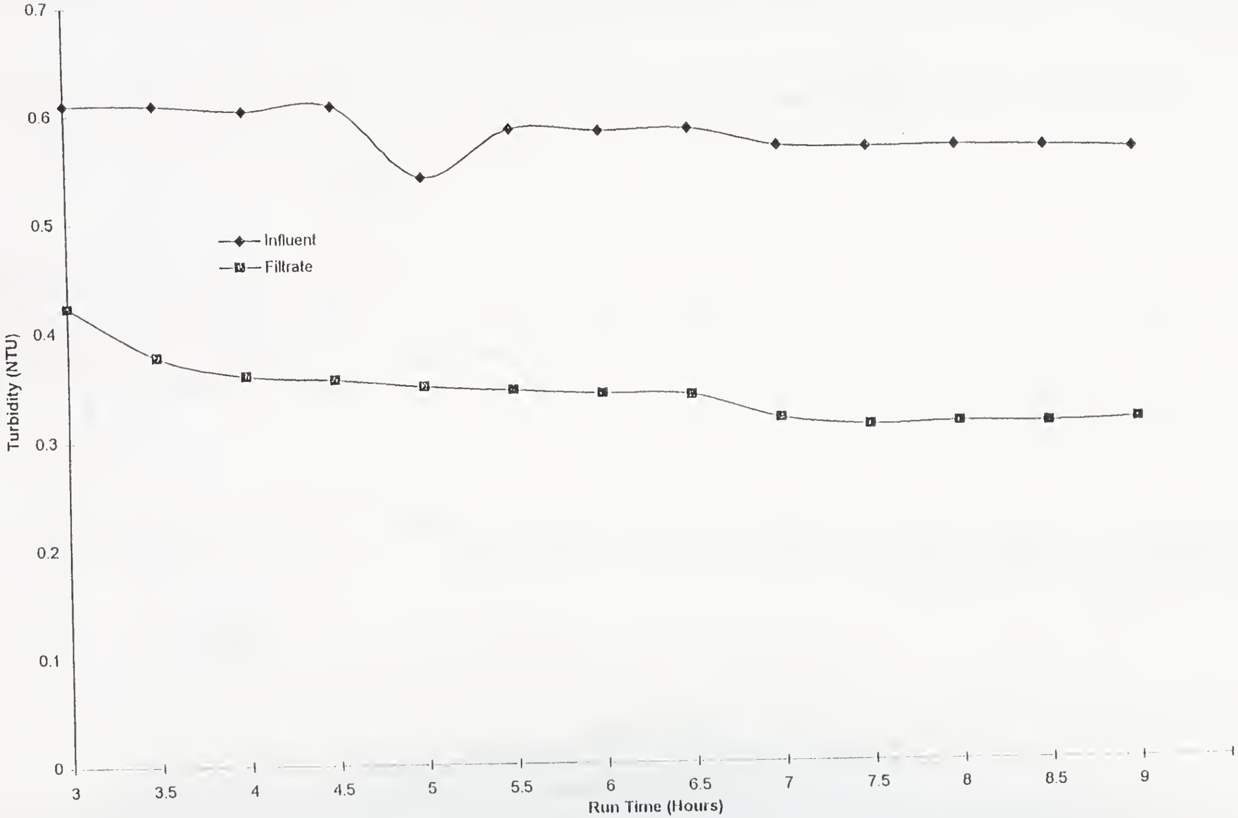


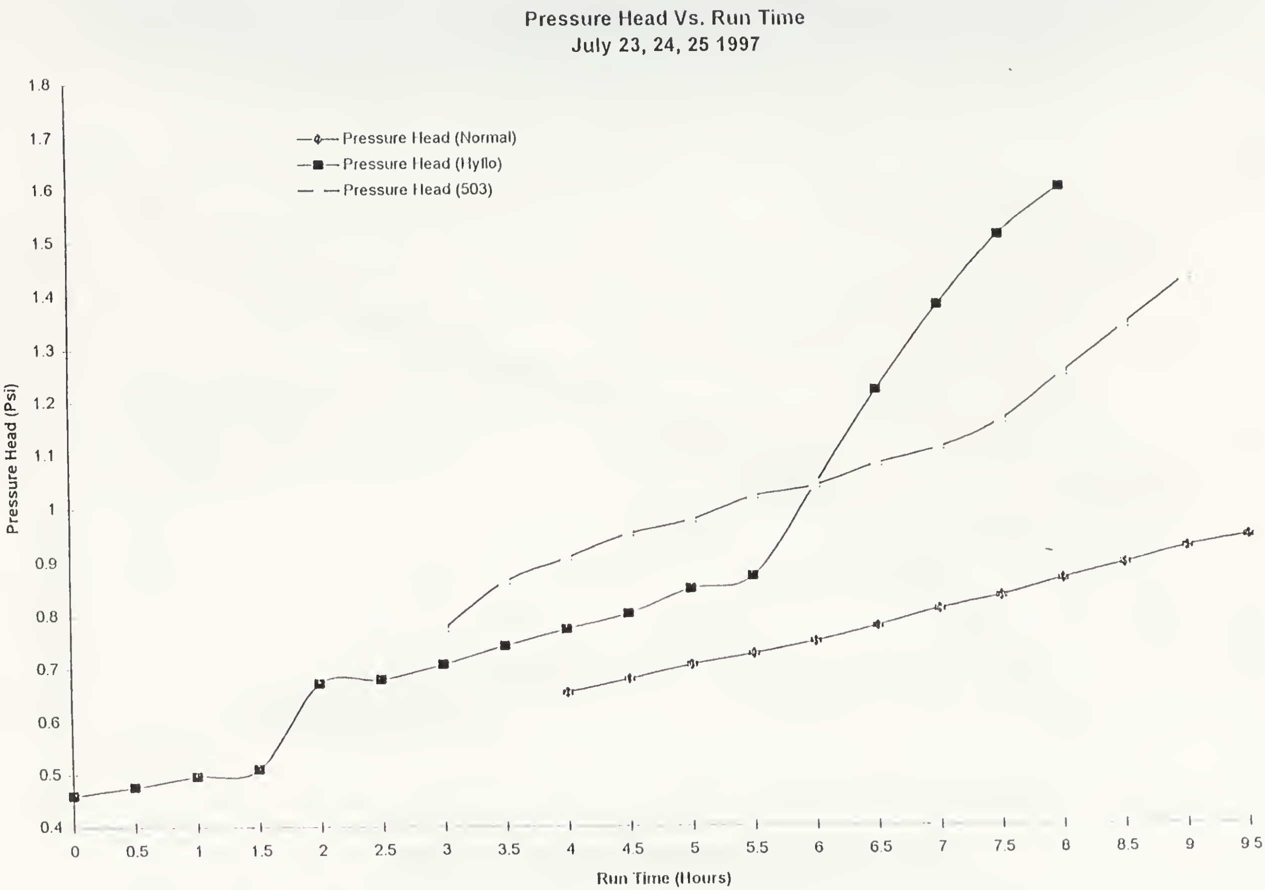
Turbidity Vs. Run Time
25 lbs. Pre-coat, normal body feed rate with normal powder
July 23, 1997

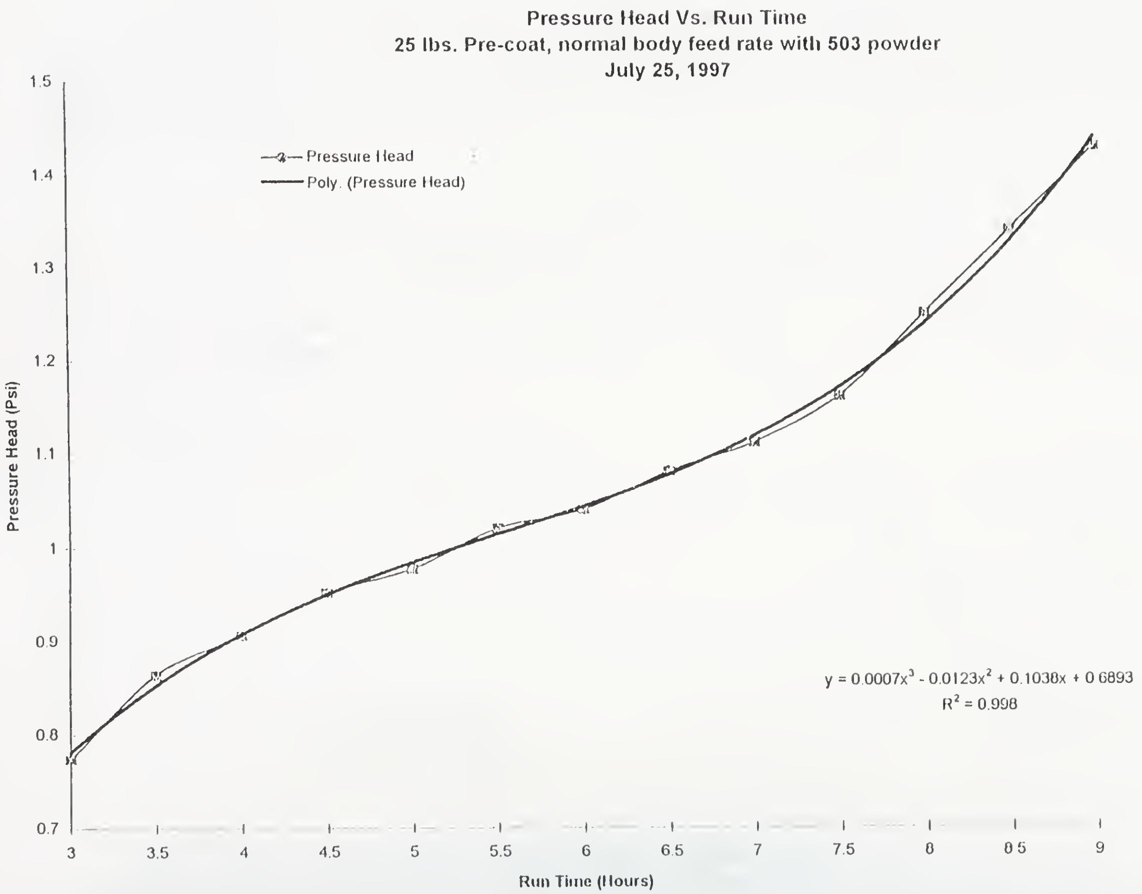


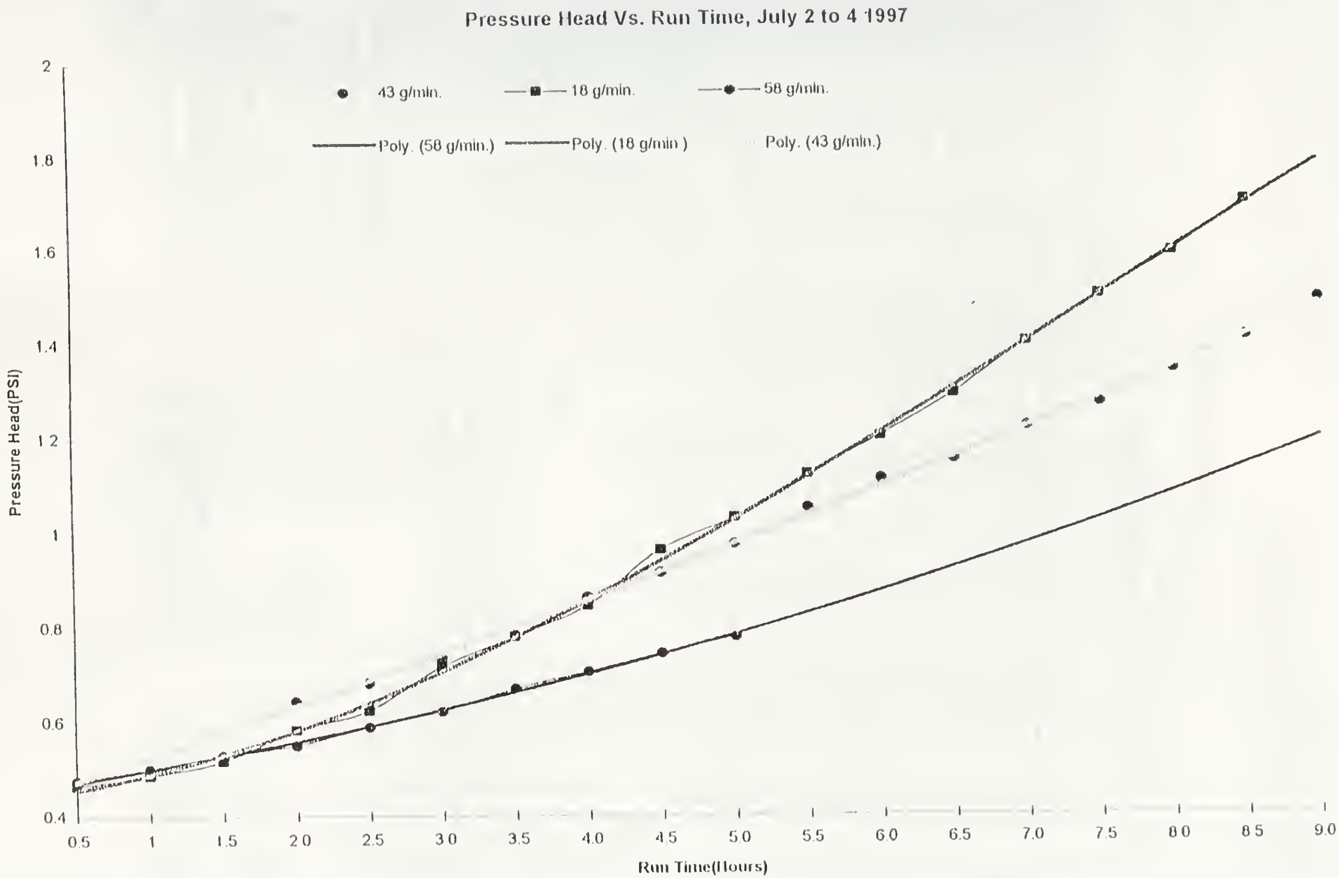

Turbidity Vs. Run Time
25 lbs. Pre-coat, normal body feed rate with Hyflo Powder
July 24, 1997
Influent
Filtrate
Turbidity (NTU)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
Run Time (Hours)

Turbidity Vs. Run Time
25 lbs. Pre-coat, normal body feed rate with 503 powder
July 25, 1997




Pressure Head Vs. Run Time
July 23, 24, 25 1997
Pressure Head (Normal)
Pressure Head (Hyflo)
Pressure Head (503)
Pressure Head (Psi)
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
Run Time (Hours)


Pressure Head Vs. Run Time
25 lbs. Pre-coat, normal body feed rate with 503 powder
July 25, 1997
Pressure Head
Poly. (Pressure Head)
Pressure Head (Psi)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
Run Time (Hours)
y = 0.0007x^3 - 0.0123x^2 + 0.1038x + 0.6893
R^2 = 0.998


Pressure Head Vs. Run Time, July 2 to 4 1997
43 g/min.
18 g/min.
58 g/min.
Poly. (58 g/min.)
Poly. (18 g/min.)
Poly. (43 g/min.)
Pressure Head(PSI)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.5
1
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
Run Time(Hours)

Wednesday, July 23, 1997

25 lbs of normal (535) pre-coat powder used
Normal (535) powder used with body feeder

RESULTS:

	Fixed Turbidity - 1720		Portable Turbidity - 2100			
Time	Influent	Filtrate	Influent	Filtrate	Pressure Head (In.H2o)	Pressure Head (Psi)
11:30 AM	0.645	0.403	0.71	0.44	18 1/8	0.654
12:00 PM	0.639	0.403	0.7	0.45	18 13/16	0.679
12:30 PM	0.632	0.406	0.73	0.45	19 9/16	0.706
1:00 PM	0.634	0.399	0.71	0.43	20 1/8	0.726
1:30 PM	0.644	0.395	0.8	0.46	20 3/4	0.749
2:00 PM	0.636	0.395	0.74	0.41	21 9/16	0.778
2:30 PM	0.599	0.396	0.68	0.41	22 7/16	0.81
3:00 PM	0.6	0.398	0.69	0.4	23 1/8	0.835
3:30 PM	0.599	0.399	0.67	0.4	24	0.866
4:00 PM	0.601	0.395	0.68	0.41	24 13/16	0.895
4:30 PM	0.6	0.397	0.63	0.4	25 5/8	0.925
5:00 PM	0.599	0.395	0.67	0.4	26 3/16	0.945
Average:	0.619	0.398	0.701	0.422	error = +-1/8	error=+-.004
Median:	0.617	0.398	0.695	0.410		
Deviation:	0.021	0.004	0.043	0.023		

Time	Flow
11:30 AM	1.5
12:30 PM	1.5
1:30 PM	1.5
2:30 PM	1.5
3:30 PM	1.5
4:30 PM	1.5
5:30 PM	1.5

Chlorine Tests

	1/2 Hour Wait		Immediately	
Time	Free	Total	Free	Total
12:35 PM	1.90*	2.620	1.310	1.870
3:35 PM	1.810	2.410	1.210	1.820

*Dilluted with 5cc Pipette

Particle Count

Size (microns)	#
2.00	942
5.00	60
10.00	1
15.00	4
20.00	0
30.00	0
40.00	0

Colour Test

Time	Colour
11:35 AM	3.000

Time	Water Temp.
11:30 AM	24.0

Thursday July 24, 1997
25 lbs. of normal (535) pre-coat powder used
Hyflo RV powder used in body feeder

RESULTS:

Fixed Turbidity - 1720 Portable Turbidity - 2100

Time	Influent	Filtrate	Influent	Filtrate	Pressure Head (In.H2o)	Pressure Head (Psi)
9:15 AM	0.587	0.708	1.07	0.66	12 3/4	0.46
9:45 AM	0.6	0.45	1.01	0.51	13 3/16	0.476
10:15 AM	0.592	0.43	0.78	0.49	13 3/4	0.496
10:45 AM	0.592	0.416	0.7	0.46	14 1/8	0.51
11:15 AM	0.58	0.429	0.69	0.44	18 5/8	0.672
11:45 AM	0.575	0.409	0.67	0.44	18 13/16	0.679
12:15 PM	0.612	0.396	0.66	0.43	19 5/8	0.708
12:45 PM	0.611	0.391	0.67	0.41	20 9/16	0.742
1:15 PM	0.61	0.371	0.66	0.4	21 7/16	0.774
1:45 PM	0.599	0.37	0.65	0.39	22 1/4	0.803
2:15 PM	0.606	0.365	0.63	0.4	23 9/16	0.85
2:45 PM	0.61	0.367	0.64	0.39	24 3/16	0.873
3:15 PM	0.619	0.37	0.65	0.4	28 3/4	1.04
3:45 PM	0.607	0.363	0.61	0.36	33 7/8	1.22
4:15 PM	0.61	0.365	0.64	0.38	38 3/16	1.38
4:45 PM	0.609	0.364	0.63	0.4	41 15/16	1.51
5:15 PM	0.606	0.366	0.61	0.39	44 3/8	1.6
Average:	0.601	0.389	0.704	0.418	error = +-1/8	error=+-.004
Median:	0.606	0.371	0.660	0.400		
Deviation:	0.012	0.082	0.133	0.071		

Time	Flow
9:00 AM	1.5
10:00 AM	1.5
11:00 AM	1.5
12:00 PM	1.5
1:00 PM	1.5
2:00 PM	1.5
3:00 PM	1.5
4:00 PM	1.5
5:00 PM	1.5

Note: The body feeder was shut off at 1:45pm

Chlorine Tests

	1/2 Hour Wait		Immediately	
Time	Free	Total	Free	Total
12:05 PM	1.340	1.880	1.600	2.410
4:05 PM	1.410	2.210	1.780	2.320

*Diluted with 5 cc pipette

Particle Count

Size(Microns)	#
2.00	982
5.00	476
10.00	36
15.00	2
20.00	2
30.00	1
40.00	0

Colour Test

Time	Colour
4:45 PM	3.000

Time	Water Temp.
12:15 PM	24.0

Friday July 25, 1997

25 lbs. of normal (535) pre-coat powder used

503 powder used with body feeder

RESULTS:

	Fixed Turbidity - 1720		Portable Turbidity - 2100			
Time	Influent	Filtrate	Influent	Filtrate	Pressure Head (In.H2o)	Pressure Head (Psi)
10:00 AM	0.61	0.423	0.69	0.47	21 7/16	0.774
10:30 AM	0.609	0.377	0.67	0.47	23 15/16	0.864
11:00 AM	0.603	0.36	0.66	0.43	25 1/8	0.907
11:30 AM	0.607	0.356	0.61	0.41	26 3/8	0.952
12:00 PM	0.541	0.349	0.6	0.4	27 1/16	0.977
12:30 PM	0.584	0.345	0.6	0.41	28 1/8	1.02
1:00 PM	0.582	0.341	0.61	0.4	28 13/16	1.04
1:30 PM	0.583	0.339	0.6	0.39	29 13/16	1.08
2:00 PM	0.567	0.317	0.59	0.38	30 3/4	1.11
2:30 PM	0.565	0.31	0.6	0.38	32 1/4	1.16
3:00 PM	0.566	0.312	0.61	0.39	34 3/4	1.25
3:30 PM	0.565	0.311	0.58	0.4	37	1.34
4:00 PM	0.563	0.314	0.56	0.37	39 3/4	1.43
Average:	0.580	0.329	0.608	0.403	error = +-1/8	error=+-.004
Median:	0.582	0.341	0.600	0.400		
Deviation:	0.022	0.032	0.037	0.032		

Note: The body feeder was shut off at 1:30pm

Chlorine Tests

	1/2 Hour Wait		Immediately	
Time	Free	Total	Free	Total
10:35 AM	1.540	1.920	*1.94	2.940
12:35 PM	1.550	1.950	*1.91	2.880

*Dilluted with 5 cc pipette

Time	Flow
9:30	1.5
10:30	1.5
11:30	1.5
12:30	1.5
1:30	1.5
2:30	1.5

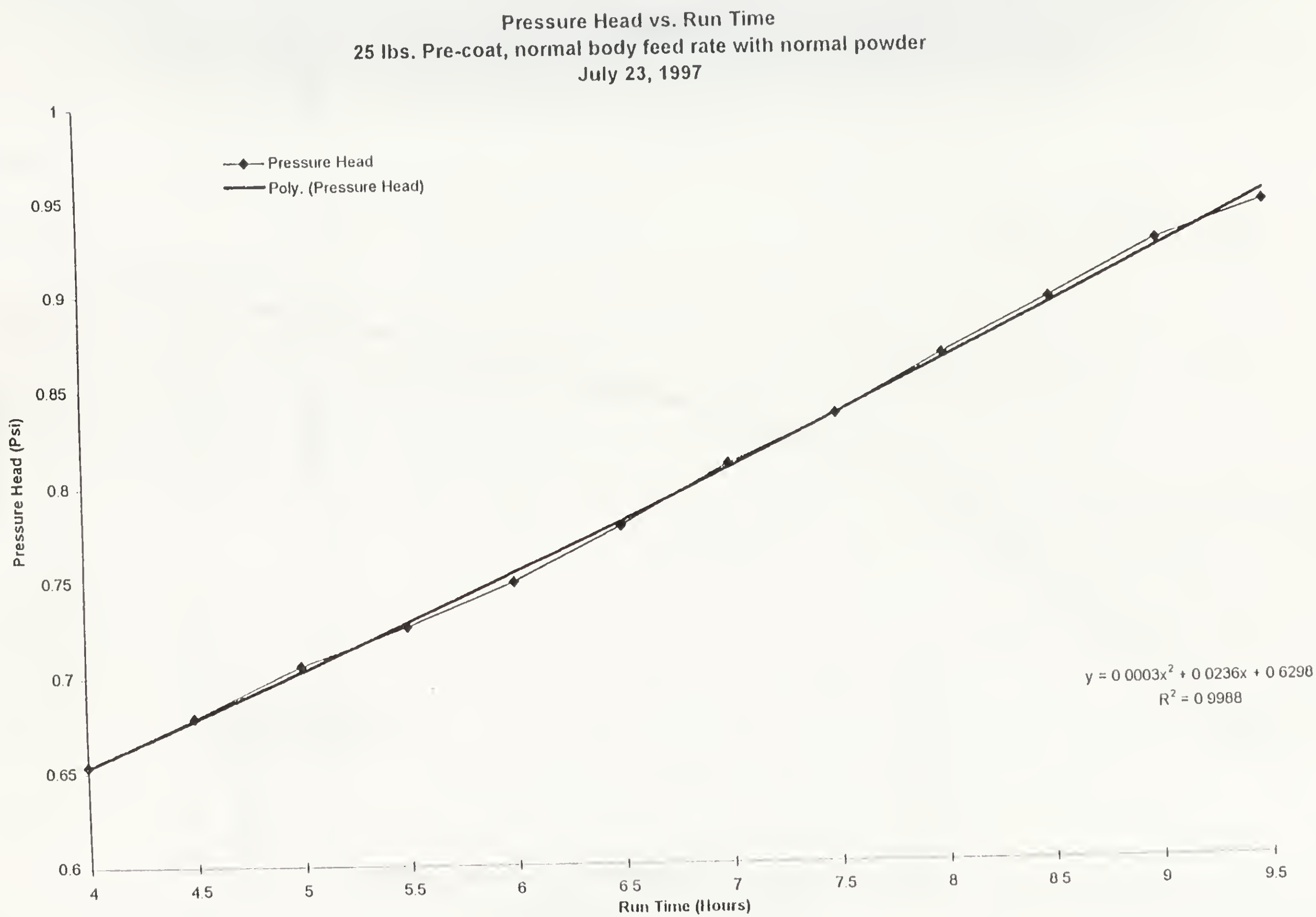
Colour Test

Time	Colour
12:40 PM	3.000

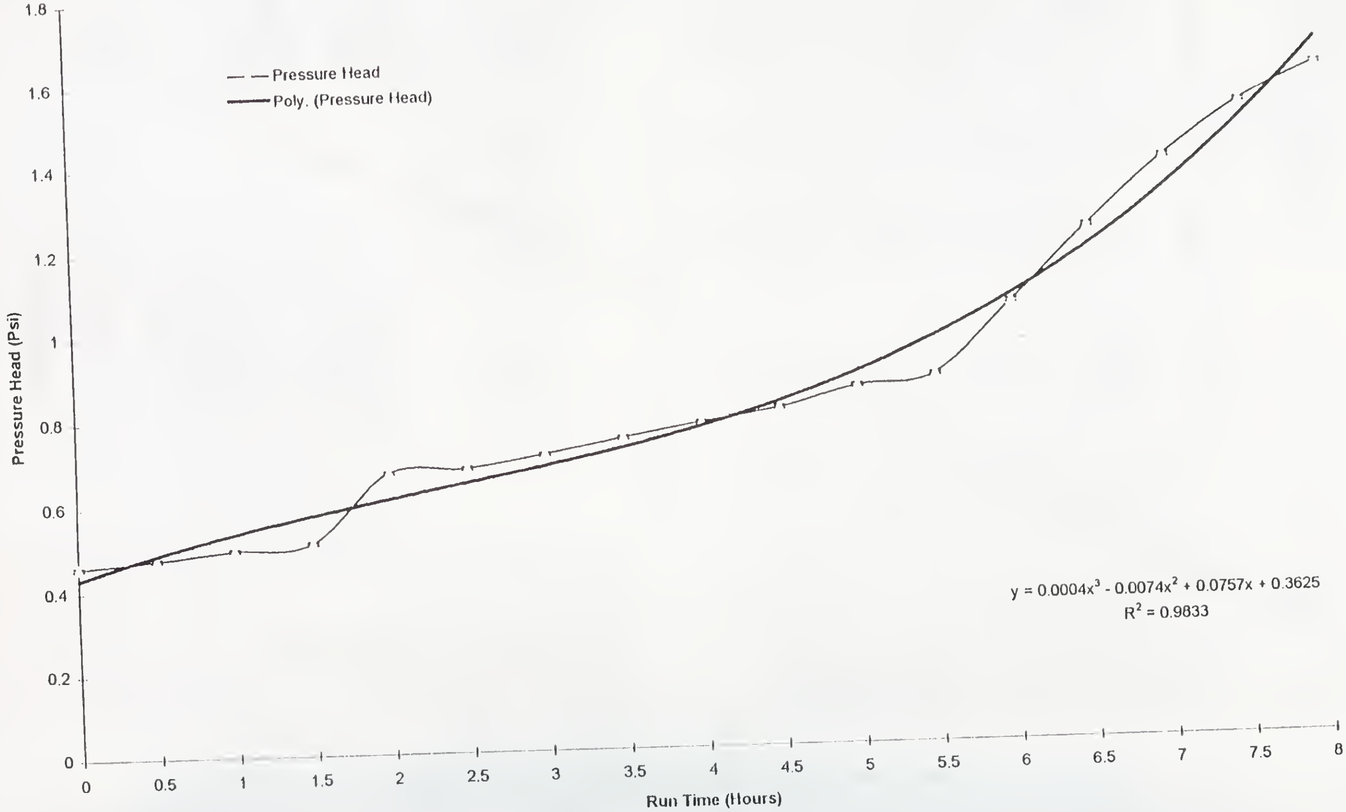
Particle Count

Size(Microns)	#
2.00	942
5.00	60
10.00	1
15.00	4
20.00	0
30.00	0
40.00	0

Time	Water Temp.
12:40 PM	24.0


Pressure Head vs. Run Time
25 lbs. Pre-coat, normal body feed rate with normal powder
July 23, 1997
Pressure Head
Poly. (Pressure Head)
Pressure Head (Psi)
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
Run Time (Hours)
y = 0.0003x² + 0.0236x + 0.6298
R² = 0.9988

Pressure Head Vs. Run Time
25 lbs. Pre-coat, normal body feed rate with Hyflo powder
July 24, 1997



Operation Manual

Appendix E

E.1 FILTER WASH DOWN PROCEDURE

The following steps should be done every day:

- Switch pump control to manual and shut off the high lift pump.
- Drain filter chamber.
- Hose down the filter plates thoroughly taking care to avoid tearing the septum.
- Refill filter chamber.
- Turn valve to recirculate position and turn on recirculating pump.
- Place 11.4 kg (25 lb) of 535 DE powder into the drum-mixer and plug in mixer motor.
- Wait until the powder and water are thoroughly mixed - two minutes should be adequate.
- Open the drain valve, and allow slurry to drain till screw can be seen, close the valve.
- Refill the drum with water, drain again and unplug the motor.
- Allow the slurry to settle in filter chamber until the septum became visible again.
- Turn the high lift pump back on and switch to automatic control.
- Fill drum to about 150 mm (6 inches) from the top with water ready for the next wash down.
- Make sure there is enough powder in the body-feed system.
- Make sure the body-feed is functioning well – approximately 40 seconds on and 20 seconds off. Increase the timer feed rate for very turbid raw water.
- Check if chlorine is being fed by weight loss from the cylinder scale.
- Check total chlorine with the colourimeter.
- Read flowmeter and record total on log-sheet.
- Read tank level and record on log-sheet.
- Make sure the Hach 1720C turbidity meter for the treated water settles to a reasonable level before leaving the plant. The turbidity of the treated water must be less than the intake turbidity. If not, try to find leak source. Record turbidities on log-sheet.
- Fill in additional columns on log-sheet and sign.
- Clean lenses of Hach 1720C turbidity meters at least once a day.

E.2 PROCEDURE FOR CHLORINE RESIDUAL MEASUREMENTS

The following procedure should be done at least once per week at the plant, and also once per week at the distant convenience store during the summer and early fall:

- With the high lift pump running, turn on cold water tap at the plant to a steady splashless stream and wait 5 minutes. For the convenience store, let the cold water run fast for at least 3 minutes and then sample.
- Make sure the 525 nm filter module is clipped into the bottom of the DR7OO colourimeter.
- Take a water sample from the tap in a Hach vial up to the half way mark.
- Insert the cleaned condensation free vial into the colourimeter. Make sure the diamond mark is at the front.
- Press power I/O button while holding down the read button to reset the lamp, and wait till the reading settles - note the reading. Press power I/O again and repeat - if the lamp reading is the same continue. If not, repeat the process till you get the same reading then press power I/O off and on again. If the readout flashes continuously change batteries.
- Press I/O twice and make sure colourimeter is set up to program 52.07.1. Use the up arrow key if needed.
- Press the zero key and wait till you see 0.00 displayed steadily.
- Take sample vial out and add the powder contents of one Hach DPD "Total Chlorine" sachet into the sample.
- Rock vial gently for about 30 seconds to make sure most of the crystals are dissolved.
- Place sample into colourimeter, wait approximately one minute and press read.
- Note the reading on the log-sheet, remove the vial and rinse it thoroughly.

E.3 PROCEDURE FOR COLOUR MEASUREMENTS

The following procedure should be done at least once every 2 weeks on a cold water sample taken from the plant sink tap.

- Make sure colourimeter is set up with the 450 nm filter module in place.
- Reset the lamp as described for the chlorine residual measurement procedure, and then turn off and on again.
- Filter clean RO water and place 10 mL into vial.
- Place wiped dry clean vial into colourimeter with the diamond mark to the front, close lid.
- Set the program to number 45.03.1 using the up arrow key.
- Press zero.
- Once zeroed, remove vial and empty.
- Filter cold tap water, and rinse out the vial with the filtered water and fill to the line.
- Insert cleaned off vial back in colourimeter with the diamond mark to the front, close lid.
- Press read and record the colour.

E.4 PROCEDURE FOR PREPARATION OF AMMONIUM SULPHATE SOLUTION

The Marmora water supply has a naturally high THMs formation potential. In the presence of free chlorine, THMs will be formed from the natural organics in the water leading to THMs exceeding the health objective level of 100 micrograms per litre. Avoiding doing disinfection using free chlorine in the distribution system is therefore recommended.

Ammonium sulphate will be added to the water leaving the chlorine contact pipe to form chloramines, and stop any further THMs formation in the distribution system. Chloramines are also known to be less reactive than free chlorine and to maintain a higher residual in the distribution system.

The procedure for dosing and preparing the ammonia solution is described as follows:

- Check free chlorine residual in the water leaving the chlorine contact pipe with the on-line chlorine analyzer.
- Adjust chlorine gas feed to give a free chlorine residual of 2 mg/L.
- Run the plant for half an hour to an hour, and check again the level of free chlorine residual.
- The ammonia solution must be made up for approximately 6 days supply.
- Dissolve 10 kg of ammonium sulphate $[(NH_4)_2SO_4]$ food grade, in 300 L of water in the day tank used for batch preparation.
- Allow adequate mixing for proper dissolution.
- Adjust the ammonia solution dosing pump to produce a total chlorine residual of 2 mg/L in the water leaving the plant.
- Verify that the level of free chlorine leaving the plant is small (+/- 0.1 mg/L).

Marmora Water Plant Logsheet

Date (Month/ Day)	Time	Vacuum Reading (psi)	Water Height in Tank (Ft)	Flow Rate (IG/Min.)	Flow Total (IG)	1720 Turbidity Intake (NTU)	1720 Turbidity Filtered (NTU)	Check Filtered less than Intake	Pwdr Prect Weight 25 lbs.	# Bags added for body feed	Timer %ON	Timer %OFF	Chlorine Total mg/L	Chlorine Scale Reading (lbs.)	Cleaned Turbid-meters (Once/ week)	Ammonium Sulphate Makeup (water/lbs. powder)	Signature

Certificate of Approval for the Chlorine Contact Pipe

Appendix F

Ministry of Environment and Energy
Ministère de l'Environnement et de l'Energie
Ontario

CERTIFICATE OF APPROVAL
WATER
NUMBER 7-0773-97-006

Village of Marmora
12 Bursthall Street, P.O. Box 417
Marmora, Ontario
K0K 2M0

You have applied in accordance with Section 52 of the Ontario Water Resources Act for approval of:

installation of a chlorine contact pipe, ammonium sulphate feed system, flow splitting system and new piping at the Marmora Water Treatment Plant located on Water Street, in the Village of Marmora, County of Hasting, as follows:

- installation of approximately 180 m of 500 mm pipe between the water treatment plant and the distribution system needed to provide the required contact time for proper chlorine disinfection;
- installation of ammonium sulphate feed system including two chemical feed metering pumps, solution preparation tank, mixer, piping, fittings, valves, power supply and all other items necessary to have a complete and operable feed system;
- flow splitting system for the existing chlorine feed system including piping, fittings, valves, rotameters and all other items necessary to have a complete flow splitting system;
- new 100 mm and 150 mm diameters piping within the treatment plant including fittings, valves, chlorine injection points and sampling lines;

all in accordance with design brief, plans and specifications as prepared by RAL Engineering Ltd., Water Supply and Wastewater Engineering.

The above noted water works are approved under Section 52 of the Ontario Water Resources Act.

DATED AT TORONTO this 12th *day of* September, 1997.

ORIGINAL CERTIFICATE MAILED
ON Sept 15/97
(Signed)

M. Dhalla, P.Eng.
Director,
Section 52,
Ontario Water Resources Act.

PF/st
Attn:-Ms. C.D. Church, Clerk-Treasurer, Village of Marmora
cc: -District Manager, MOEE Peterborough District Office
-Mr. R. LeCraw, P.Eng., RAL Engineering Ltd.

Public Notification for Changing to Chloramination

Appendix G

A CHANGE IN MARMORA'S WATER TREATMENT

Beginning in the late winter of 1998, the Marmora Water Treatment Plant will use chloramines instead of chlorine to disinfect water. Many places in Ontario including Metropolitan Toronto Water Treatment Plant, use chloramines as a disinfectant. Chloraminated water is the same as chlorinated water for all of the normal uses we have for water.

However, there are two groups of people who need to take special care with chloraminated water: kidney dialysis patients and fish owners. Chloramines must be removed from water used in the kidney dialysis process and from water that is used in fish tanks or ponds.

This article will help you understand chloramines. If you think you might be affected by this change, we urge you to seek professional assistance.

What are Chloramines?
Chloramines are a combination of chlorine and ammonia which are used to kill potentially harmful bacteria in water. Chloramines have been used safely throughout the United States and Canada for many years. Metropolitan Toronto is one of the many places in Ontario which use chloramines as part of their water treatment process.

Why is Marmora changing to chloramines?
Like many other communities Marmora has experienced elevated levels of trihalomethanes (THM's) when using chlorine as a disinfectant. Chlorine reacts with naturally occurring organic materials in the source water to form THM's.

THM's are suspected carcinogens. The Ontario Ministry of the Environment (MOE) guidelines currently set at a standard of 100 parts per billion, based on a running annual average of four quarterly samples. The water from Marmora averages THM levels of approximately 123 parts per billion.

The use of chloramines will enable Marmora to continue to provide its customers with water that is both safe to drink and aesthetically appealing. The U.S. Environmental Protection Agency recommends chloramines as a disinfectant and as a way to avoid THM formation.

Why are chloramines a problem for kidney dialysis patients and fish owners?
Chloramines are harmful when they go directly into the bloodstream. In the dialysis process, water comes in contact with the blood across a permeable membrane. Chloramines in dialysis water would be toxic, just as chlorine in dialysis water would be toxic. Fish also take chloramines directly into their bloodstreams.

What special precautions should kidney dialysis patients take?
Chlorine and chloramines must be removed from the water used in kidney dialysis

machines. There are two ways to accomplish this, by adding ascorbic acid or by using granular activated carbon treatment.

Medical centers that perform dialysis are responsible for purifying the water that enters the dialysis machines.

Dialysis systems already pre-treat their source water to remove chlorine, However, some modifications will be necessary to remove the chloramines.

Home dialysis service companies can usually make the needed modifications, but you should check with your physician to be certain.

If you have any questions, please consult your physician.

Can people with kidney ailments on low-sodium diets, or with diabetes drink chloraminated water?
Yes. People with those medical problems can use chloraminated water for all purposes.

What special precautions should fish owners take?
Chloramines should be removed from water that is used in fish tanks or ponds. This includes lobster tanks at grocery stores and restaurants, as well as fish containers at bait shops.

Chloramines are toxic to fish, reptiles, turtles and amphibians, just as chlorine is toxic and must be removed. You may not have had to remove chlorine from your aquarium water, however, because it disappears rapidly on its own. This is not the case with chloramines and steps must be taken to remove chloramines.

Chloramines can be removed from the water by using a water conditioner containing a dechlorinator or by using granular activated carbon. These are available at your pet store.

If you have any questions, please consult your pet store.

What are the effects of ammonia on fish?
Ammonia can be toxic to fish, although all fish produce some ammonia as a natural by product. Ammonia is also released when chloramines are chemically removed. Although ammonia levels may be tolerable in individual tanks or ponds, commercial products are available at pet supply stores to remove excess ammonia. Also, biological filters, natural zeolites and pH control methods are effective in reducing the toxic effects of ammonia.

Are both salt and fresh water fish affected by chloramines?
Chloramines will have to be removed if the water used to make the salt-water solution comes from an agency receiving water from Marmora. Chloramines affect saltwater fish just as they affect fresh water fish.

If chloramines are harmful to fish, how can people safely drink the water?
Chloraminated water is no different than chlorinated water for all of the normal uses we have for water. Water that contains chloramines is totally safe to drink. The digestive process neutralizes the chloramines before they reach the bloodstream. Even kidney patients can drink and bathe in chloraminated water.

Can pregnant women and children drink chloraminated water?
Yes. Everyone can drink water that contains chloramines.

What about people who are sensitive to chemicals?
The amount of chloramines will be extremely small-no more than 2.0 parts per million parts of water. That is the maximum amount in the water as it leaves the Marmora filtration plant. If you are concerned that even this low concentration might cause problems for you, check with your physician

What will water taste like with chloramines?
If you notice any change at all, you may find the water has less of a chlorine odor or taste.

Can you safely wash an open wound with chloraminated water?
Yes. It is safe to use chloraminated water in cleaning an open wound because virtually no water actually enters the bloodstream that way.

Will chloramines affect your swimming pool?
No. You will still need a free chlorine residual to retard algae and bacteria growths. DPD test kits measure free chlorine residuals and can be used with confidence. Contact your local pool supply stores for specfic information.

Will chloramines change the pH of the water?
No. The pH of Marmora's water will remain in the range of pH 6.9 to 7.7.

Can you safely water plants, vegetables or fruit and nut trees?
Yes. The small amount of chloramines should have no effect on plants of any type. Beneficial bacteria will generally be protected by the soil in which they live. Chloramines will be removed by the high chlorine demand in the soil.

Do home water purifiers remove chloramines?
Most home purifiers are not designed to remove chloramines. Consult your manufacturer for specific information.

Will reverse osmosis remove chloramines?
No. Salts can be caught by the permeable membranes, but chloramines pass through easily.

Will chloramines dissipate, or dissolve, out of the water?
No. Unlike chlorine, which dissipates when water sits for a few days, chloramines may

take weeks to dissipate.

Will chloramines be removed by boiling the water?
No, boiling is not an effective method of removing chloramines from water. The only practical methods of removing chloramines from water are using a water conditioner which contains a dechlorinator or by using granular activated carbon.

Will chloraminated water used for agricultural purposes have any effect on fish in adjacent streams?
Most water which runs into streams and ponds would be agricultural, landscaping or storm water drainage. After water has been used for one purpose, it probably would not have enough residual chloramine to affect fish.

Where to call?
If you have any questions about Marmora's water process please call The Village of Marmora at 472-2533.

If you have any questions about kidney dialysis, please call your physician.

If you have any questions concerning the care of fish, please call your pet store.

A CHANGE IN MARMORA'S WATER TREATMENT WILL AFFECT YOUR AQUARIUM TREATMENT PROCEDURES

Beginning in the late winter of 1998, the Marmora Water Treatment Plant will use chloramines instead of chlorine to disinfect water. Chloramines are a combination of chlorine and ammonia.

Many places including Metropolitan Toronto use chloramines as a disinfectant. Chloraminated water is no different than chlorinated water for most of the normal uses we have for water.

However, chloramines are toxic to fish, reptiles, turtles and amphibians and must be removed from water, just as chlorine is toxic and must be removed.

You may not have had to remove chlorine from your aquarium water, because it disappears rapidly on its own. This is not the case with chloramines and steps should be taken to remove chloramines.

You can use two methods to remove chloramines from water: add specific agents which will remove chloramines and ammonia, or use a high grade of granular activated carbon. In either case, you should purchase a home test kit to test your aquarium water for total chlorine and ammonia.

Dechlorinating Agents
Most pet stores have sold dechlorinating agents for years and, generally, have recommended using them. The chemicals used to remove chlorine will also remove the chlorine part of the chloramines. It may take more dechlorinating agent and it may take more time. Ammonia is released when you use dechlorinating agents to remove chloramines from the water and additional steps should be taken to also remove the ammonia.

Removal of Ammonia
Ammonia can be toxic to fish, although all fish produce some ammonia as a natural by-product. Commercial products are available at pet supply stores to remove excess ammonia. Also, biological filters, natural zeolites and pH control methods are effective in reducing the toxic effects of ammonia. Ammonia removal is particularly important in water with a high pH, because at a higher pH, ammonia is more toxic to fish. Marmora's water is in the 6.9-7.7 pH range, which is moderate.

Activated Carbon Filters
Chloramines can also be removed by using a high grade of granular activated carbon. It is important that you allow the appropriate amount of contact time for chloramine removal using this method. Treatment of large volumes of water with activated carbon filters is very involved and you should seek professional assistance.

Home Test Kits
It is essential that you test the water in your aquarium or fish pond to be sure the

chloramines and ammonia have been reduced to acceptable levels. Home test kits are available at most pet stores.

Remember, you can use two methods to remove chloramines from water:

1. Add specific agents which will remove chloramines and ammonia.
2. Use a high grade of granular activated carbon to remove chloramines

Contact your pet store for home test kits and other supplies.

For additional information on chloramines, contact
The Village of Marmora at 472-2533